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WADC TECHNICAL REPORT 52-268

SECURITY INFORMATION

ELECTRONIC INSTRUMENTATION FOR THE STUDY OF AIR-TO-AIR ELECTROMAGNETIC WAVE PROPAGATION AT 250, 1000, AND 3000 MC

STANLEY B. WHITE
AIRCRAFT RADIATION LABORATORY

AUGUST 1952

WRIGHT AIR DEVELOPMENT CENTER

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ELECTRONIC INSTRUMENTATION FOR THE STUDY OF AIR-TO-AIR ELECTROMAGNETIC WAVE PROPAGATION AT 250, 1000, AND 3000 MC

Stanley B. White
Aircraft Radiation Laboratory

August 1952

RDO No. 112-73

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Dayton, Ohio
150 February, 1953

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FOREWORD

This report was prepared for the Aircraft Radiation Laboratory, Directorate of Laboratories, Wright Air Development Center, on Research and Development Order No. 112-73, High Altitude Radio Frequency Propagation, with Mr. Ming S. Wong acting as project engineer. The author is indebted to Mr. Garner B. Fanning and Captain Fred P. Miller of Aircraft Radiation Laboratory for valuable support of the work described in this report.

ABSTRACT

This report describes the electronic instrumentation devised for air-to-air electromagnetic wave propagation measurements at the 250, 1000, and 3000 mc ranges. Propagation studies were made with square-wave modulation at 245 and 1000 mc, and with short-pulse modulation at 256, 2880, and 3295 mc. (The results of some of the propagation flights have been reported in Air Force Technical Reports 6208 and 6254.)

In the instrumentation utilizing square-wave modulation, the transmitter was modulated at a crystal-controlled frequency, and a narrow-band filter-amplifier (18 cycles bandwidth) was used in connection with the radar receiver. In the instrumentation utilizing short-pulse modulation, a peak reader with an internally generated carrier was used in connection with the radar receiver. The rectified output from either the filter-amplifier or peak reader operated a recorder which continuously recorded the received signal on an approximately logarithmic scale.

The receiving system using square-wave modulation can detect and record signals 107 db below a milliwatt, and it has a dynamic range of well over 100 db. The short-pulse receiving system can detect and record signals down to the noise level of the receiver proper, and it has a dynamic range of well over 85 db.

The two systems as developed around the filter-amplifier and the peak reader have operated in a highly satisfactory manner, and can be used with existing radio and radar equipment.

The security classification of the title of this report is UNCLASSIFIED.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

Donald J. Reams
for CLARENCE H. LEWIS
Colonel, USAF
Chief, Aircraft Radiation Laboratory
Directorate of Laboratories

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SECTION I - INTRODUCTION

The instrumentation described in this report was necessary in order to investigate air-to-air electromagnetic propagation phenomena. The investigation was brought about because of the unexplainable failure of aircraft to maintain high-frequency air-to-air radio and radar contact within the line-of-sight range.

When the Wave Propagation Section of Aircraft Radiation Laboratory began making air-to-air propagation flights, the aim was to gather simultaneously as many types of data as practical. Effects of frequency, polarization, modulation, terrain, and meteorological elements were to be measured under prevailing atmospheric conditions in each flight. Some of the data collected have been analyzed and published (References 1 and 2). A description of a recording psychrograph, for measuring meteorological data during the flights, has also been published (Reference 3).

This report describes the electronic instrumentation used to measure the radio field-intensity at frequencies near 250, 1000, and 3000 mc. To save time and funds, it was planned to use existing transmitters, signal generators, and receivers to the greatest extent possible. Two types of transmitters were available: one of the low-power CW type; the other of the high-peak-power short-pulse type. The transmitters and signal generators used were modified for either square-wave or short-pulse modulation. The receivers used have broad-band IF amplifiers. Wherever possible, the IF amplifier bandwidth was adjusted for optimum operation, taking into consideration transmitter frequency drift, type of modulation, local oscillator frequency drift, and ease of tuning. Stability of the receiving equipment was greatly improved by regulating the AC input and the DC plate voltages.

After much experimentation, therefore, two measuring systems were developed, one utilizing low-peak-power square-wave modulation; the other, high-peak-power short-pulse modulation. Usually the system used on a particular frequency was the one which gave the greater loop gain.

For the system using square-wave modulation, a crystal-controlled modulator and a narrow-band audio filter-amplifier unit were specially designed. This sharp audio filter greatly reduced the noise level in the receiving system, thus allowing weaker signals to be detected. The same result could have been achieved by an instrumentation using narrow-band IF amplifiers. However, the use of narrow-band audio filters permitted the use of existing equipments which did not have the frequency stability necessary for narrow-band IF operation. Furthermore, the use of relatively broad-band IF amplifiers tremendously reduced the problems of RF frequency drift.

For the short-pulse modulation, a special peak reader was developed. This instrument measures the envelopes of the pulse amplitude for amplitude levels down to the noise level of the radar receiver proper.

The received signals, for both the square-wave and short-pulse types of modulation, were recorded on Esterline-Angus or Brush Recorders. An approximately logarithmic scale was used for the field-intensity amplitude. For this purpose an AGC feedback circuit was developed which uses variable-mu or remote cut-off tubes in the IF amplifier stages where the AGC voltage is applied.

The receiving system using square-wave modulation can detect and record signals 107 db below a milliwatt, and it has a dynamic range of well over 100 db. The short-pulse receiving system can detect and record signals down to the noise level of the receiver proper, and it has a dynamic range of well over 85 db.

SECTION II - INSTRUMENTATION USING SQUARE-WAVE MODULATION

The equipments for square-wave modulation, as shown in Fig. 1, include a modified CW or noise-modulated jammer type of transmitter (with average power varying from 60 to 200 watts), signal generator, crystal-controlled square-wave generator, radar receiver, cathode-ray monitoring scope, filter-amplifier unit, recorders, associated antennas and power supplies. (See Tables I and II of Section V for list of specific equipments used at 245 and 1000 mc.)

The transmitters and RF signal generators, used at various frequencies, were modified so they could be square-wave modulated by a single type of crystal-controlled square-wave generator. This square-wave generator and the filter-amplifier unit were developed and fabricated specially for propagation measurements.

In the square-wave generator circuit, Fig. 2, a crystal oscillator is followed by four clipper amplifiers. Four isolated output circuits are provided on each generator so that four transmitters or signal generators can be driven at one time. The square-wave output has an amplitude of 250 volts and a leading and trailing edge of 5 microseconds.

The filter-amplifier unit, Fig. 3, consists of an input video gain control followed by a stage of amplification, a filter tuned to 1.818 kc, two more stages of amplification, an output transformer, a selenium rectifier, and an AGC feed-back control. The filter consists of two toroidal coils having a Q of 200 link coupled, one coil being in the plate circuit of the first amplifier tube and the other in the grid circuit of the second amplifier. The first amplifier tube has a high AC plate resistance so that full advantage could be taken of the high Q of the toroidal coils. The control of the AGC circuit allows any percentage of the output voltage to be fed back to the IF amplifier for calibration purposes. It is very important that the AGC be fast acting so the recorders will not overshoot, and that it be low in impedance so the feed-back will remain negative and thus not produce unwanted low-frequency oscillations in the system.

The noise level of the square-wave receiving system is approximately 108 db below a milliwatt. This figure varies to some extent with the type of radar receiver and the bandwidth of the receiver IF amplifier. The 1.818 filter-amplifier reduces the noise and increases the sensitivity by a factor of from 15 to 25 db, depending on the bandwidth of the receiver IF amplifier.

The output from the filter-amplifier operates an Esterline-Angus and a Brush Recorder simultaneously, but either one may be disconnected without affecting the other. The Brush Recorder is shunted with a 700-ohm resistance, and the Esterline-Angus Recorder is in series with 27,000 ohms. These resistances give proper operation and damping of the recorders. At the same time, both recorders read full scale at the same signal level.

Figures 4 and 5 show several calibrations made on Esterline-Angus tapes for the square-wave type of receiving system. These figures were obtained using various settings of (1) the AGC, which controls the percentage of automatic gain of feedback voltage, and (2) the overall gain of the receiving system. Figure 6 replots the output-signal calibrations contained in Figs. 4 and 5, and shows the flexibility of the receiving system for accommodating widely different ranges of signal.

SECTION III - INSTRUMENTATION USING SHORT-PULSE MODULATION

The equipments for short-pulse modulation are shown schematically in Fig. 7 to include a short-pulse transmitter of high peak power, a short-pulse modulated RF signal generator, a radar receiver, a monitor scope, a specially designed peak reader, recorders, and associated antennas and power supplies. (See Tables III, IV and V of Section V for list of specific equipments used at 256, 2880, and 3295 mc.)

The transmitters, used at various frequencies, emit pulses of from 0.6 to 2 microseconds in length, 300 to 930 times a second in pulse repetition frequency, and 18 kilowatts to 1 megawatt in peak power. The signal generators simulated the modulation characteristics of the transmitters except for the 0.6-microsecond pulse used in one propagation link. This produced very little error in calibration, because the receiver had the bandwidth necessary for the short pulse and the peak reader was insensitive to the discrepancy in pulse width concerned.

The specially designed peak reader can be used with any type of short-pulse receiver to measure the amplitude of the received pulses. Connection of the peak reader to the receiver is simple and consists mainly of providing a means for applying the AGC voltage from the peak reader to the IF amplifier of the receiver in a suitable manner. As shown in Fig. 8, the peak reader consists of a gain control followed by a video stage, a pulse polarity switch, another video stage, a cathode follower, a peak reading diode, another cathode follower, a converter tube, a power output tube, an output transformer, a selenium rectifier, an AGC voltage feedback control, and a carrier oscillator.

In conjunction with the polarity switch, the first video stage provides a means for selecting the proper pulse polarity to allow the first cathode follower to charge condenser C_1 through diode V4. The cathode follower always requires a positive pulse as the pulse is applied to the plate of the diode. The charging time of the cathode-follower diode and condenser C_1 combination is made short so that one pulse will effectively charge C_1 to the peak voltage of the received pulse. It is this short charging time plus a relatively long discharging time, governed by the resistance R_1, which make the peak reader relatively insensitive to pulse width. The value of R_1 is chosen by taking into consideration repetition frequency, recorder response, and signal fluctuation frequency. Isolation of the diode circuit is furnished by the second cathode follower (V5) which has a high-value cathode resistor for reducing the grid current that might influence the discharging time of the diode circuit. The second cathode follower allows an additional time constant between the diode and the converter tube. This extra time constant has the effect of a ripple filter and reduces shock excitation of the system which would produce undesirable damped oscillation if a step-function type of large signal amplitude were applied to the receiver input. The extra time constant also controls the response of the system and eliminates unwanted continuous low-frequency oscillation. Feedback tending to produce the undesired damped or continuous oscillation occurs through the AGC circuit.

A carrier system is used, as shown in Fig. 8, to apply the DC variations to the AGC voltage divider and recorder circuits. This carrier system is free from drift problems common in DC amplifiers. The carrier is introduced at the injector grid of the tube V6(6L7). The pulsating DC signal from the second cathode follower is applied to the control grid of V6, causing the AC output of V6 to vary in proportion to the received signal. This output is then amplified by V7 and rectified by a selenium rectifier loaded by a 700-ohm resistor and the recorders. The carrier is furnished by a Franklin oscillator operating at 5500 cycles per second and at an output of 15 to 18 volts in amplitude. The bias on V6 is adjusted so that, without signal at the input of the video amplifier, the recorder shows a small deflection. This adjustment is semipermanent.

It is desirable that the carrier frequency of the peak reader be such that the fundamental or the harmonics of the pulse repetition frequency do not beat with the peak-reader carrier and produce spurious excursions of the recorder pen. This problem of beats is eliminated by having the carrier frequency much higher than the pulse repetition frequency.

Figure 9 shows the dependence of the peak-reader response on the pulse length and on the pulse repetition frequency. The curves shown were obtained using a constant pulse amplitude.

SECTION IV - TEST UNIT FOR MEASURING DYNAMIC RESPONSE OF RECEIVING SYSTEMS

In operation there are two controls to be adjusted in calibration of the receiving system. These adjustments are similar in either the square-wave or short-pulse reception. They are made on the gain and on the AGC feedback controls in the filter-amplifier or the peak reader (See Figs. 2 and 8). The gain is adjusted so that the weakest signal level to be encountered, or noise, is indicated at zero deflection on the recorder chart. The AGC feedback is adjusted so that the strongest signal to be encountered is indicated at full scale deflection on the recorder chart.

The recorded radio signals as measured in propagation flights usually undergo various degrees of fluctuations — with various fluctuation frequencies and amplitudes. Because of limitations imposed by the response time of the recorders, and also of the other parts of the receiving system, the fluctuation amplitudes of the recorded signals are usually compressed — especially when the fluctuation frequencies are high relative to the response time. For the purpose of determining the dynamic response characteristics of the receiving systems, a test unit has been designed which is near final completion. This test unit can be used on either an over-all receiving system or some of its components, and can be used on either the square-wave or short-pulse type of receiving system.

A simplified block diagram of the test unit, which will be fully described in a future report, is shown in Fig. 10. The basic parts of the unit include a sine-wave generator and an IF oscillator, amplifier, and attenuator. The amplifier is either square-wave or short-pulse modulated, by an external modulator, and is modulated at the same time by the sine generator. This sine modulator consists of two 85-kc oscillators and associated circuitry, such that it gives an output with variable percentage modulation and with excellent waveform for frequencies from a fraction of 1 cps to 500 cps. Thus the output of the amplifier is in the form of either square waves or short pulses whose amplitudes are sine-wave modulated.

Figure 11 shows the frequency response characteristics, measured by the test unit at three constant signal levels, of an over-all receiving system, using a Brush Recorder.

SECTION V - SPECIFIC PROPAGATION EQUIPMENTS USED FOR VARIOUS FREQUENCY RANGES

The specific propagation equipments used at various frequencies, in air-to-air and air-to-ground propagation, are listed in Tables I - V.[1] Propagation measurement with square-wave modulation has been made at 245 and 1000 mc; with short-pulse modulation, at 256, 2880 and 3295 mc. The special equipments which had to be developed — crystal-controlled square-wave generator, filter-amplifier, peak reader, and test unit — have been described in previous Sections. The modifications which had to be made in adapting existing equipments to propagation measurements are described in the Appendix.

Photographs of some of the equipments in Tables I - V are shown in Figures 12 - 20. Figure 15 shows the bottom view of a peak reader where annular-shaped terminal strips can be seen surrounding the tube sockets. These annular terminal strips have proved very useful in building vacuum-tube circuits.

The asterisks in Tables I - V indicate the equipments of which modifications are described in the Appendix. Handbooks of Maintenance Instructions for the equipments mentioned in the Tables are given in the List of References (4-10 and 12 and 13) Handbooks of Maintenance Instructions on the AN/APS-10 and AN/APS-34 are also listed in the References (References 11 and 14), since the AN/APS-10 and AN/APS-34 have IF strips very useful in fabricating radar receiving equipment for propagation measurements.

1/ Some air-to-ground measurements were made at the same time as the air-to-air measurements; however, the air-to-ground measurements were given secondary consideration.

TABLE I

SQUARE-WAVE MODULATION EQUIPMENTS AT 245 MC

* Radar Transmitter T-75/APT-4

* Modulator MD-30/APT-4

Rectifier Power Unit PP-87/APT-4

* Signal Generator LAF-3

Square-Wave Generator

* Radio Receiver AN/APR-4

* Tuning Unit TN-17/APR-4

Indicator ID-59/APA-11 (monitor scope)

Filter-Amplifier

* Esterline-Angus Recorder

* Power Supply RA-88

Antennas: Vertical dipoles (half above and half below wing) in the airplanes; a quarter-wave vertical antenna over a 16 feet x 30 feet screen at the ground.

TABLE II

SQUARE-WAVE MODULATION EQUIPMENTS AT 1000 MC

* Radar Transmitter T-85/APT-5A

  Rectifier Power Unit PP-104/APT-5

* Signal Generator TS-601(XA)/U

* Radio Receiver AN/APR-4

  Tuning Unit TN-18/APR-4

  Indicator ID-59/APA-11 (monitor scope)

  Filter-Amplifier

* Esterline-Angus Recorder

* Power Supply RA-88

  Antennas: 7-element Yagi (11-db gain) in the airplanes; horn (15-db gain) at the ground.

TABLE III

SHORT-PULSE MODULATION EQUIPMENTS AT 256 MC

* Transmitter T-11/APN-3
  Indicator ID-17/APN-3
  Signal Generator LAF-3
* Radio Receiver AN/APR-4
* Tuning Unit TN-17/APR-4
  Indicator ID-59/APA-11 (monitor scope)
  Peak Reader
* Power Supply RA-88
* Esterline-Angus Recorder
  Antennas: Same as in Table I.

TABLE IV

SHORT-PULSE MODULATION EQUIPMENTS AT 2880 MC

* Radar Transmitter AN/APS-20
  Signal Generator TS-403
* Radio Receiver AN/APR-4
  Special Tuning Unit (See Appendix)
  Indicator ID-59/APA-11 (monitor scope)
  Peak Reader
* Esterline-Angus Recorder
* Power Supply RA-88
  Antennas: Primary feed of AN/APS-20 antenna and a 15-db horn in the airplanes; an 18-db horn at the ground.

TABLE V

SHORT-PULSE MODULATION EQUIPMENTS AT 3295 MC

Special Short-Pulse Transmitter (See Appendix and Fig. 17)

Modulator BC-1142-A/SCR-720

Signal Generator TS-403

* Radar Receiver RT-39A/APG5 (Fig. 18)

Indicator ID-59/APA-11 (monitor scope)

Peak Reader

* Esterline-Angus Recorder

* Power Supply RA-88

TRANSTAT Voltage Regulator TF-12A/APQ-13

Antennas: A dipole with a 3.5-inch disk reflector and a 15-db horn in the airplanes; an 18-db horn at the ground.

SECTION VI - CONCLUSIONS

The instrumentation descrit·d in this report was developed on the basis of existing Air Force equipments ·ith a minimum of effort and expense, and fulfills the intended purpose. I· can easily be adapted to different frequencies and types of measureme t. Operational reliability and stability of the equipments have been very satisfactory.

.'he large a: unt of data which can be collected on each flight, as a resul of propag ing at several frequencies simultaneously, enables correl..ions to be made between a wide diversity of causes and propagation effects.

In operation it has been found that, for a given propagation link, it is easier to achieve a high over-all loop gain by square-wave modulating the transmitting and using a sharp filter-amplifier than by increasing the transmitter power and using continuous-wave propagation. Square-wave modulation of the transmitter and the use of the filter-amplifier permit very definite identification of the transmitted signal.

As applied to short pulses, the peak reader is superior to the filter-amplifier.

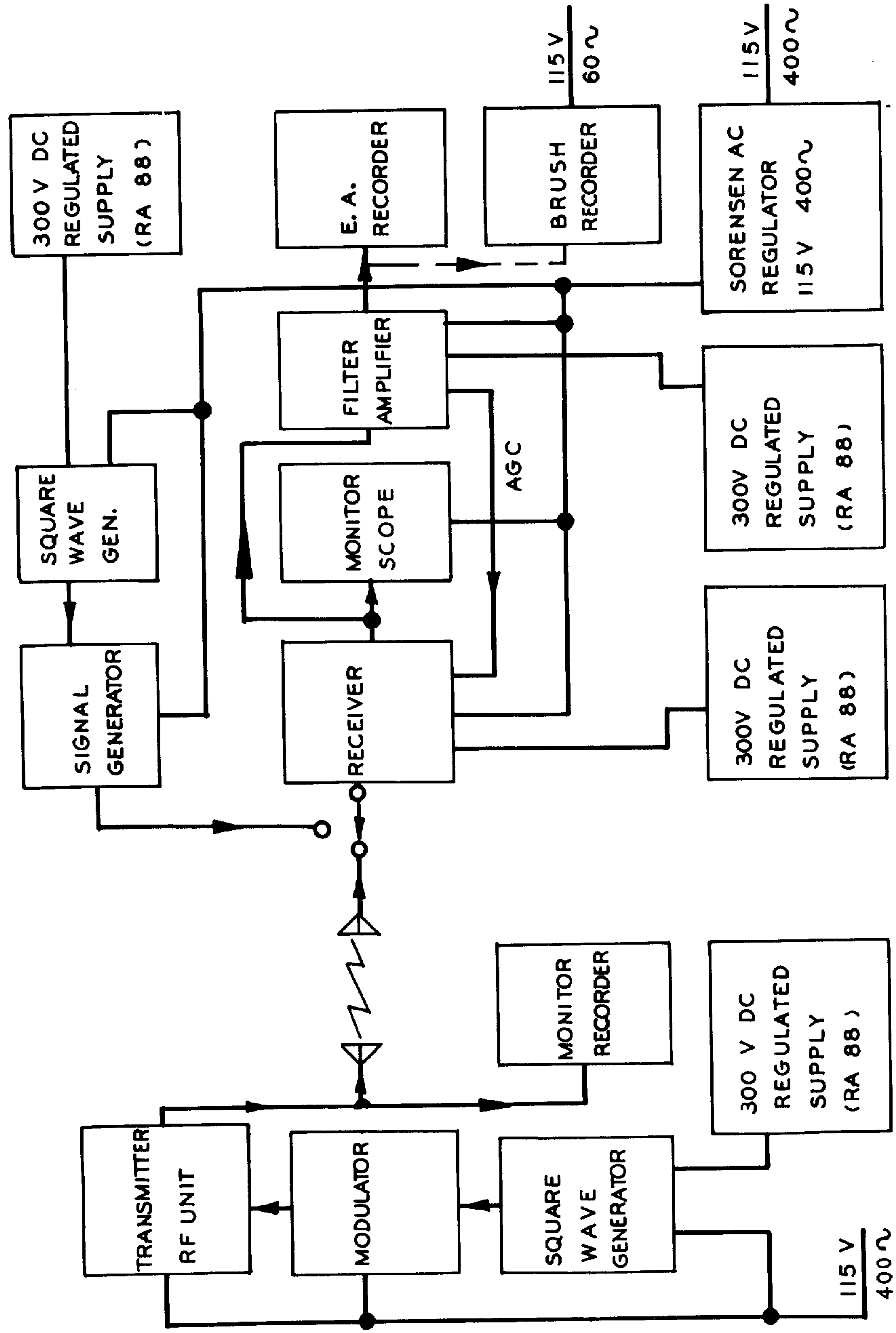


Fig. 1. Block Diagram: Square-Wave Type of Instrumentation

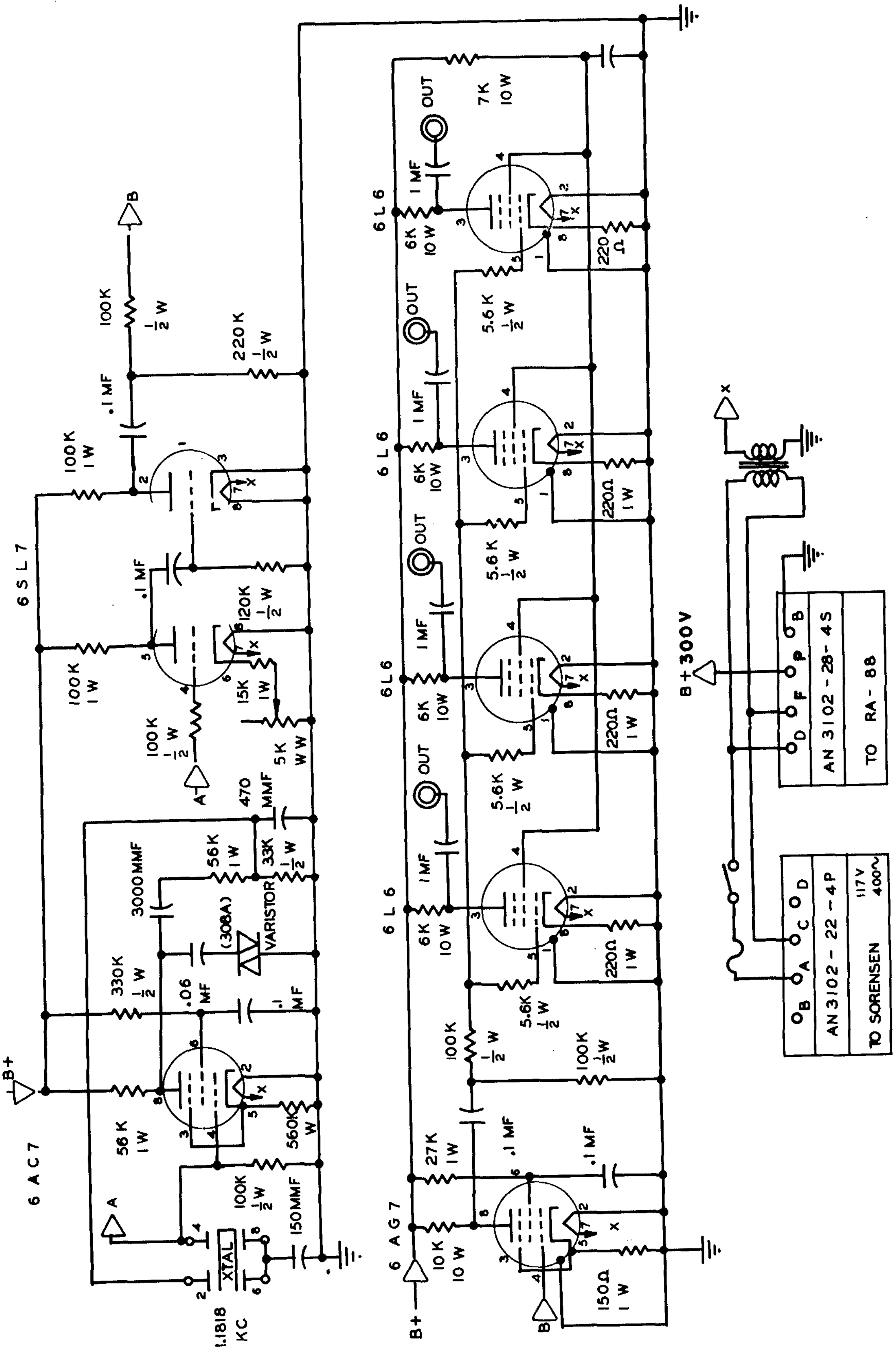


Fig. 2. Schematic Diagram: Square-Wave Generator

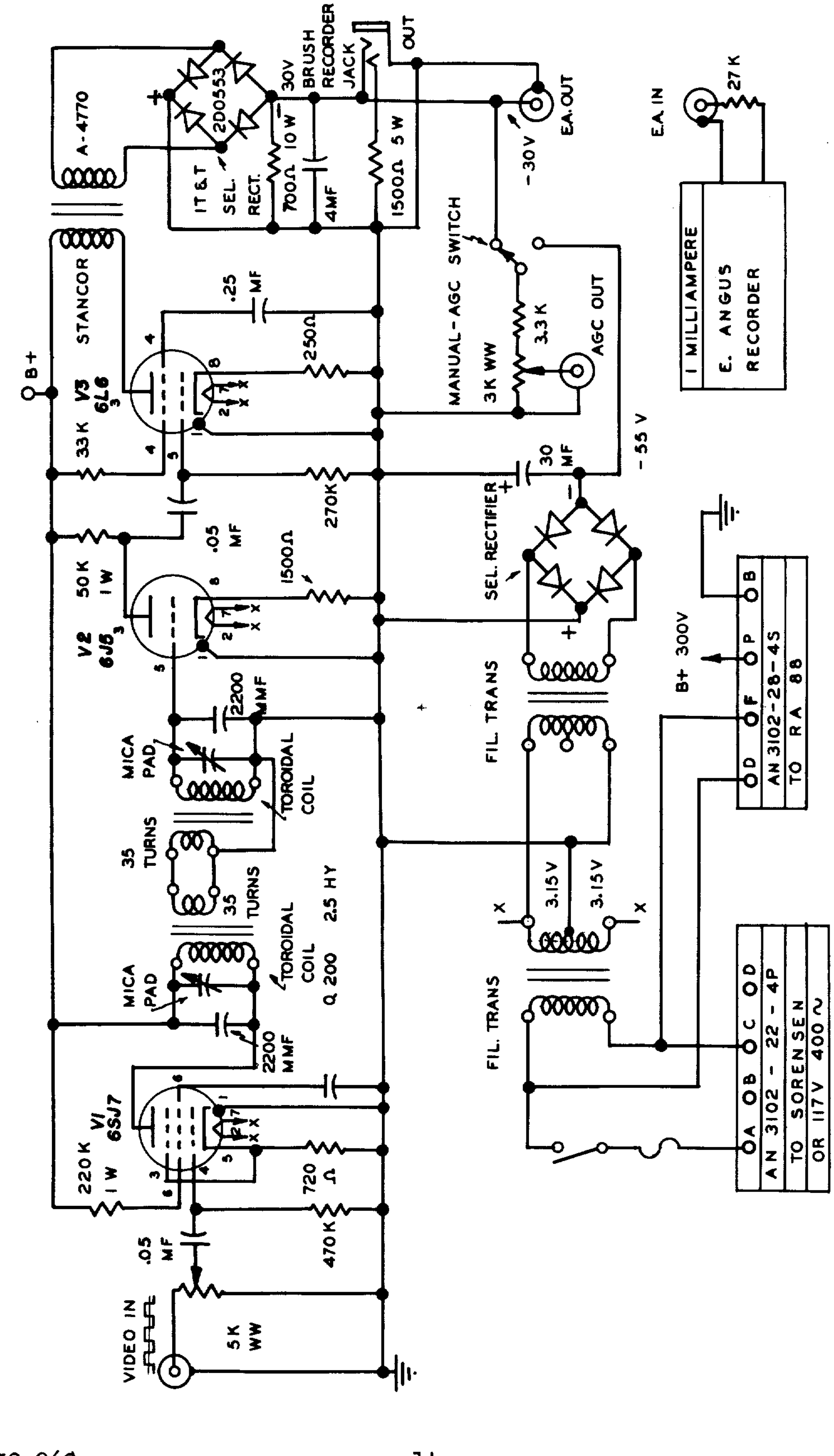


Fig. 3. Schematic Diagram: Filter Amplifier

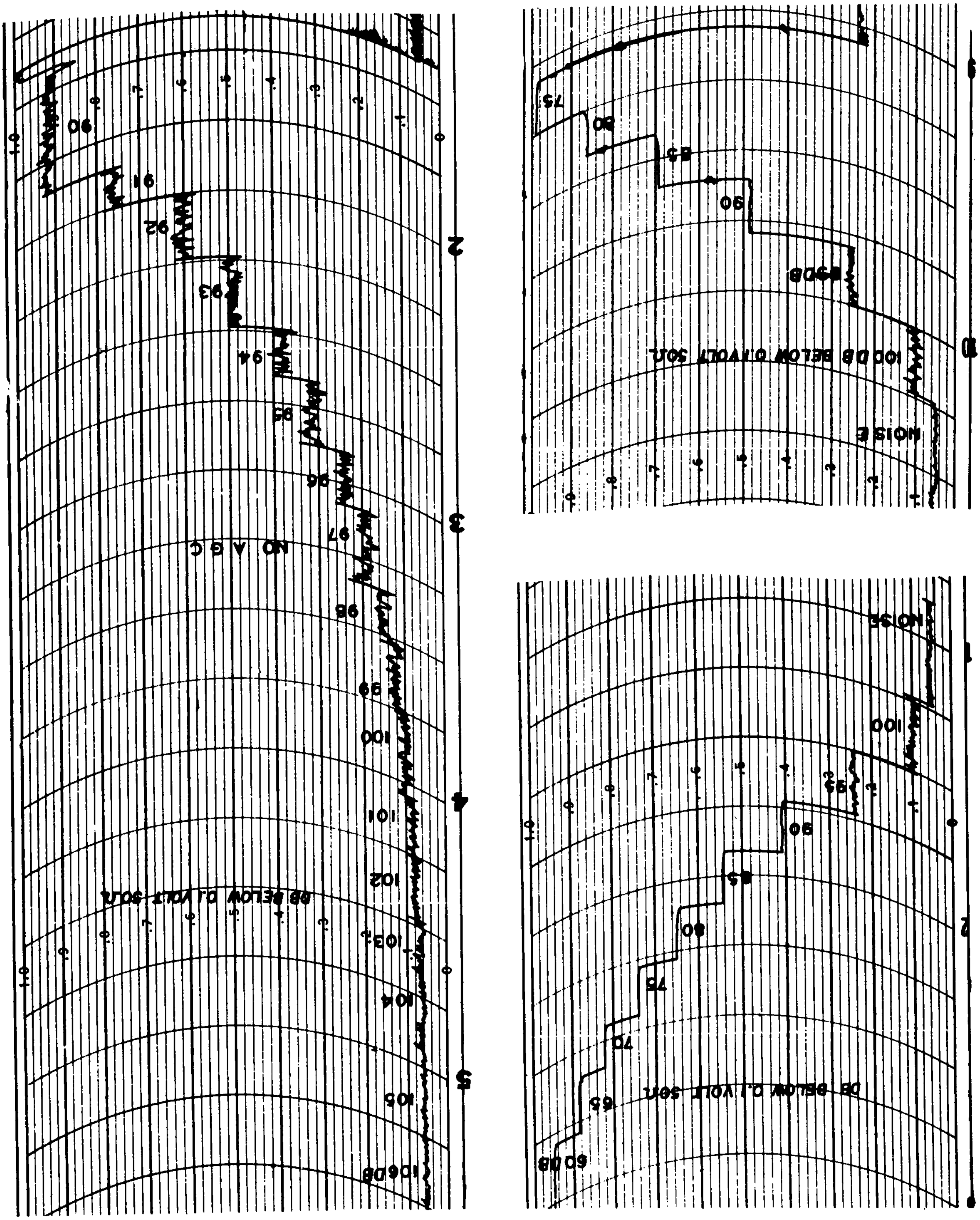
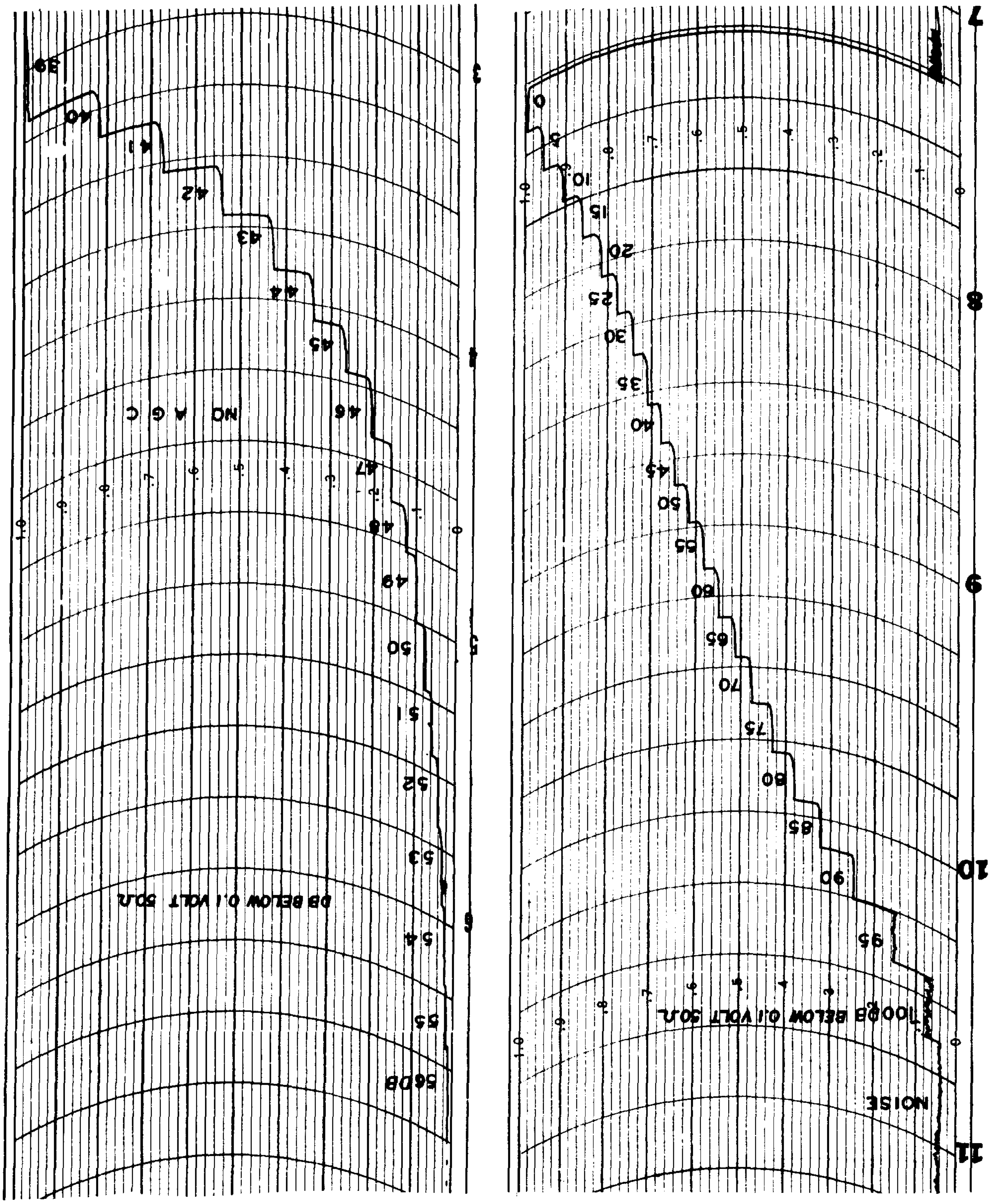


Fig. 4. Typical Calibrations - Square Wave


NO A G C
DB BELOW 0.1 VOLT 50Ω
56DB
100DB BELOW 0.1 VOLT 50Ω
NOISE

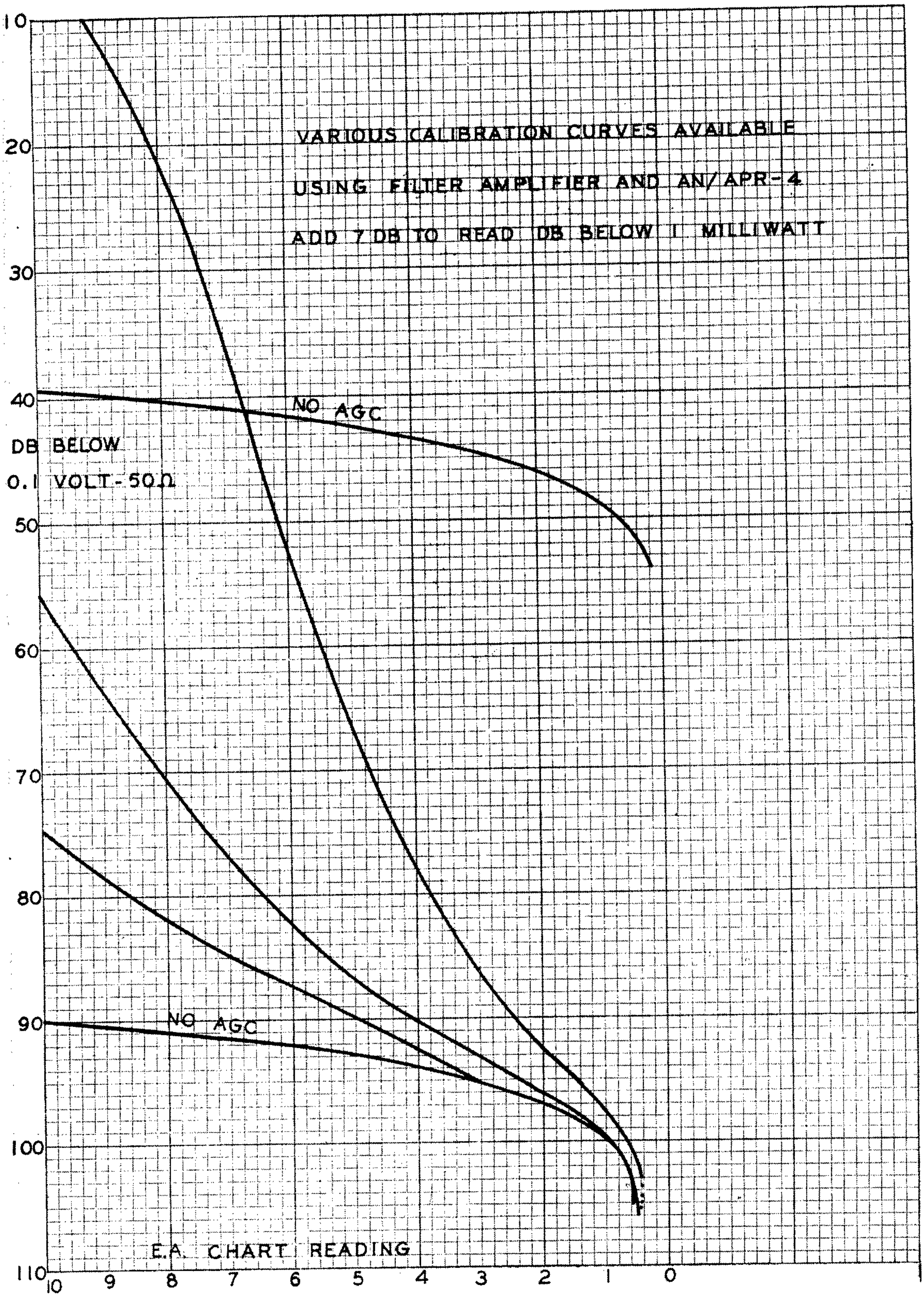


Fig. 6. Various Calibration Curves Available Using Filter Amplifier and Receiving Equipment AN/APR-4

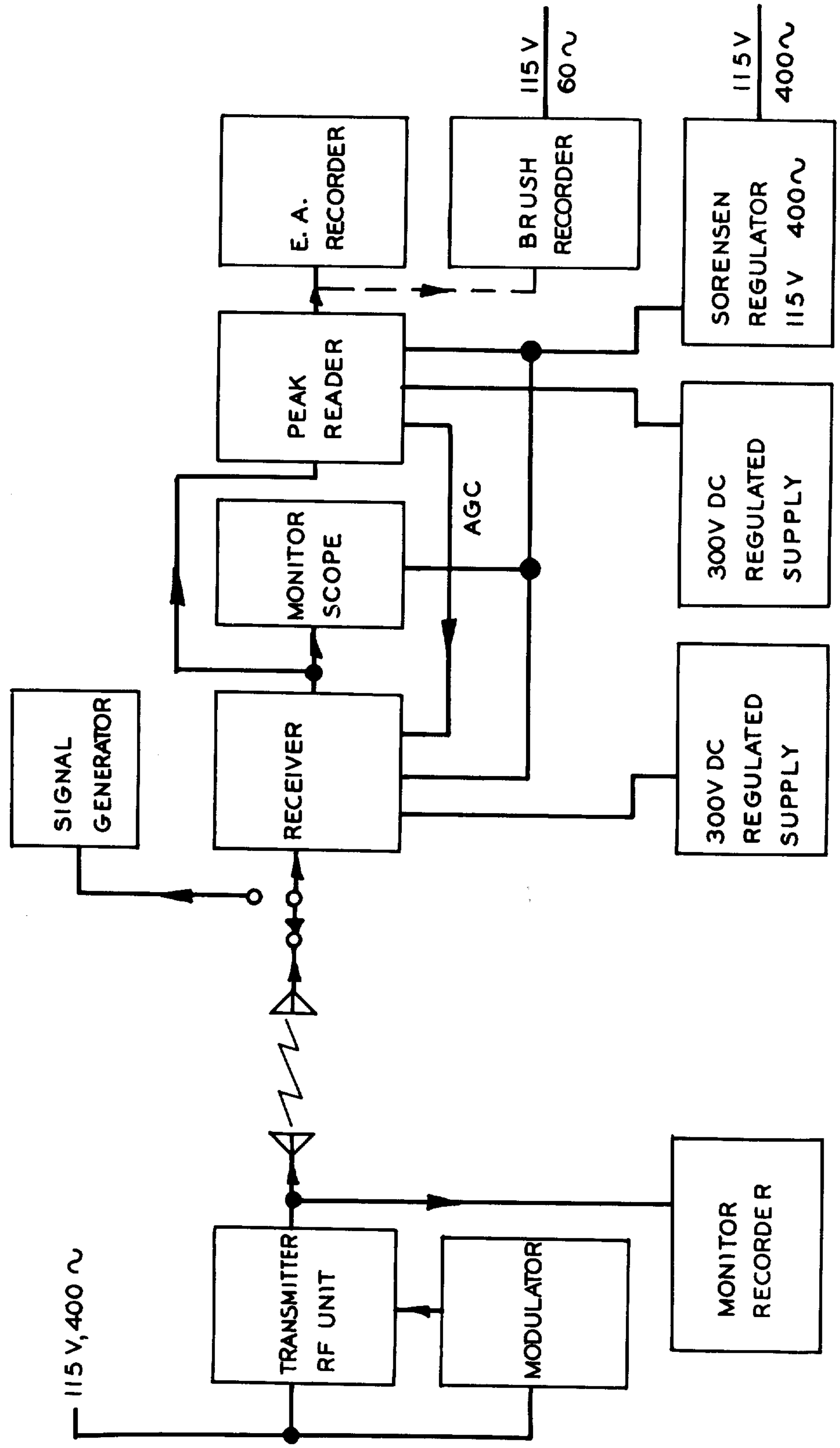
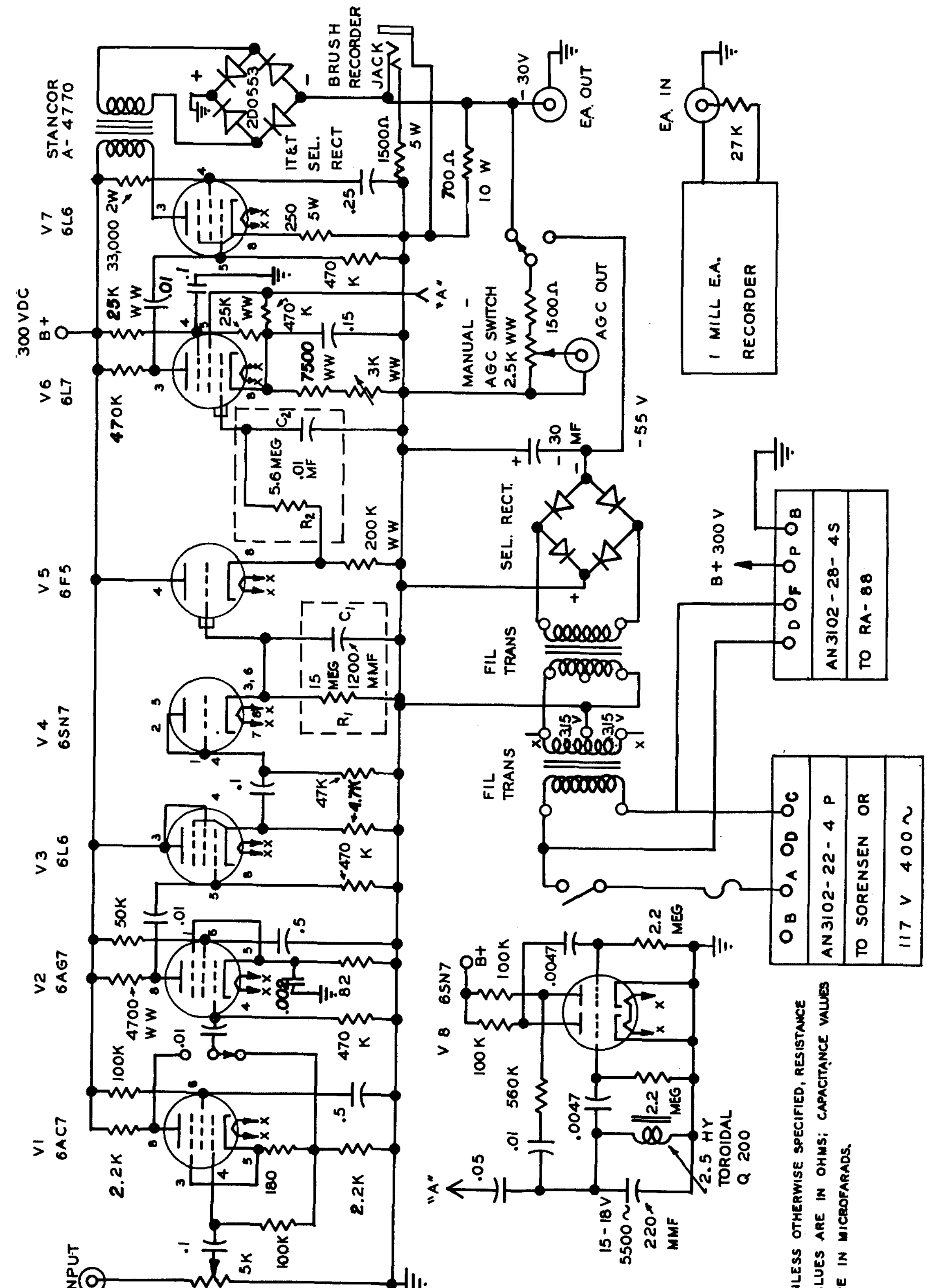


Fig. 7. Block Diagram: Short-Pulse Type of Instrumentation



UNLESS OTHERWISE SPECIFIED, RESISTANCE VALUES ARE IN OHMS; CAPACITANCE VALUES ARE IN MICROFARADS.

Fig. 8. Schematic Diagram: Peak Reader

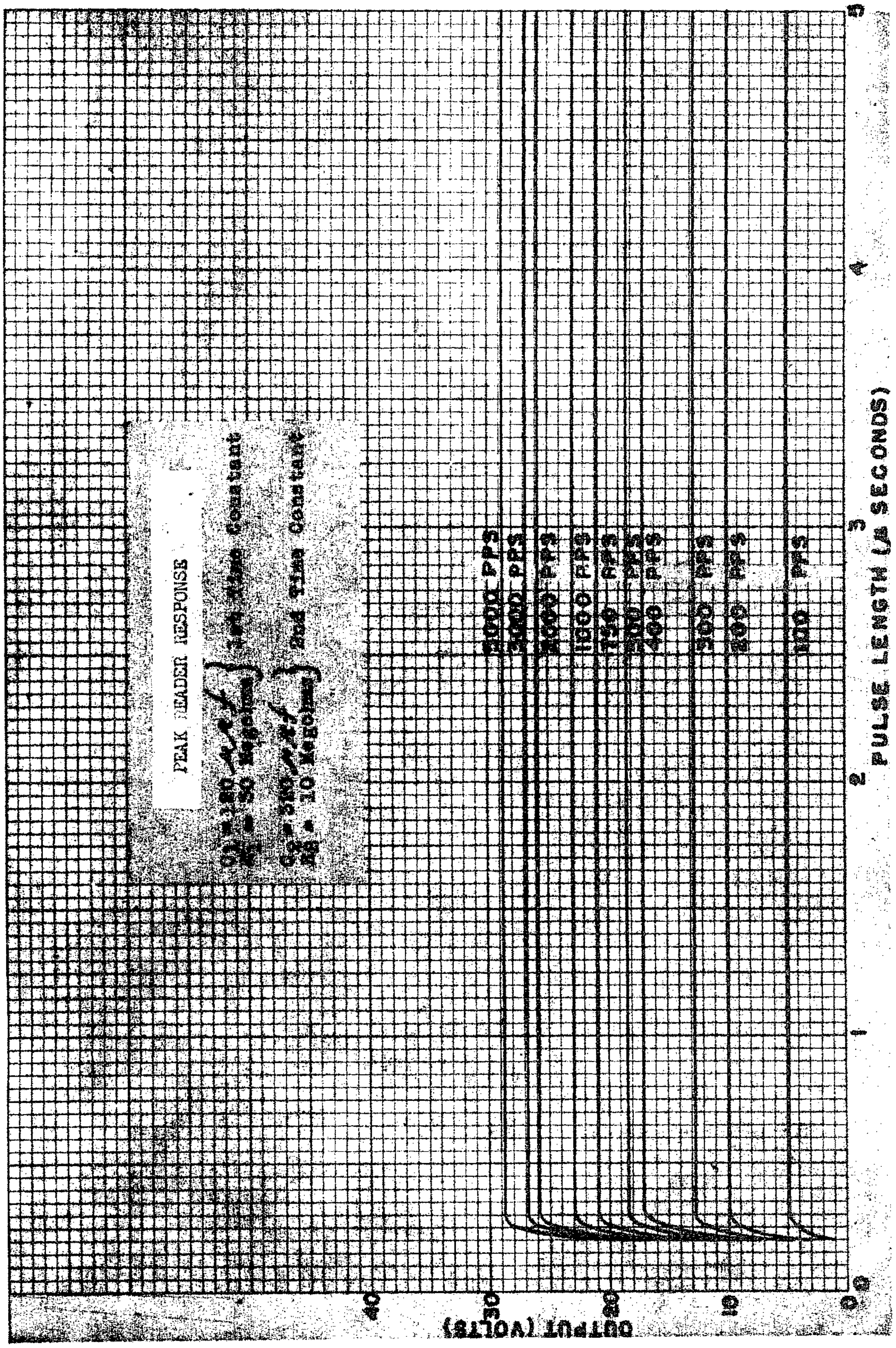


Fig. 9. Peak Reader Response

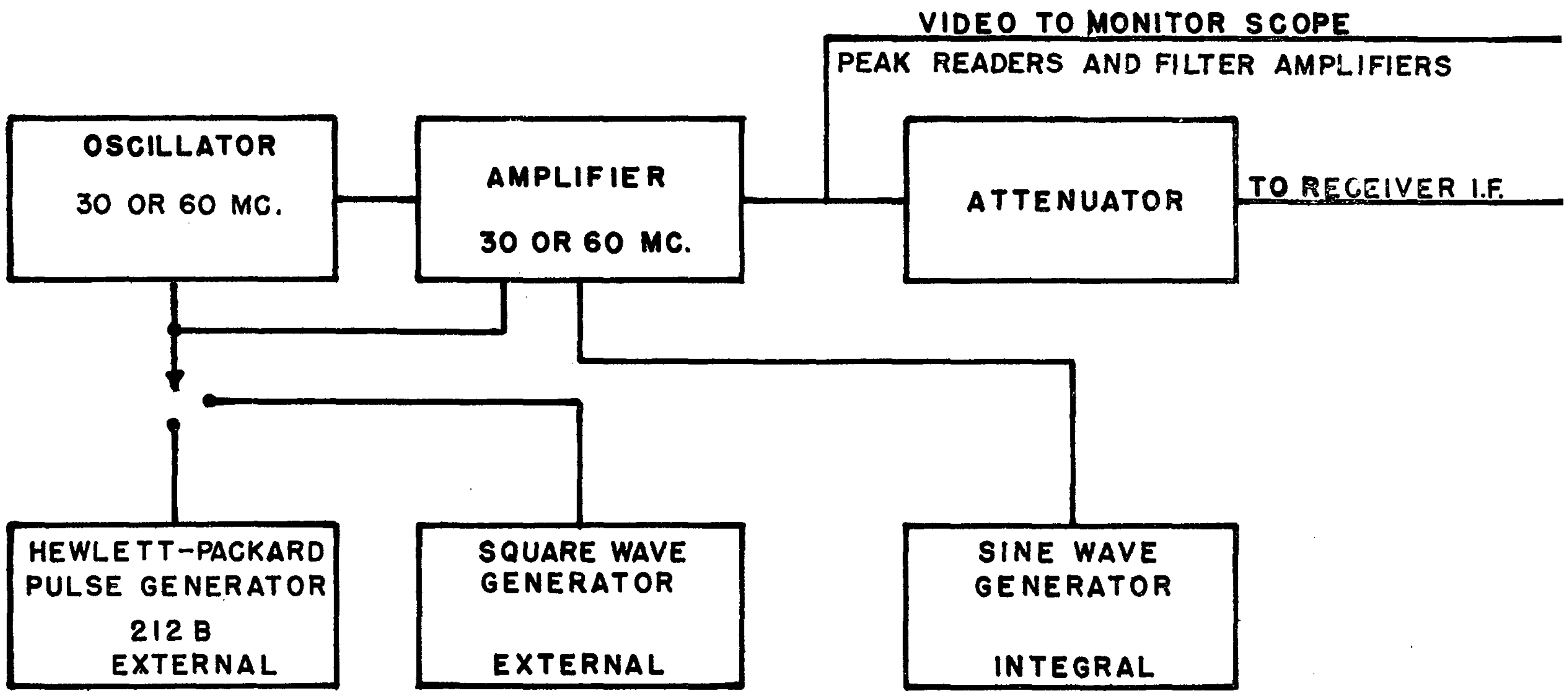


Fig. 10. Simplified Block Diagram of Test Unit for Measuring Dynamic Response of Receiving Systems

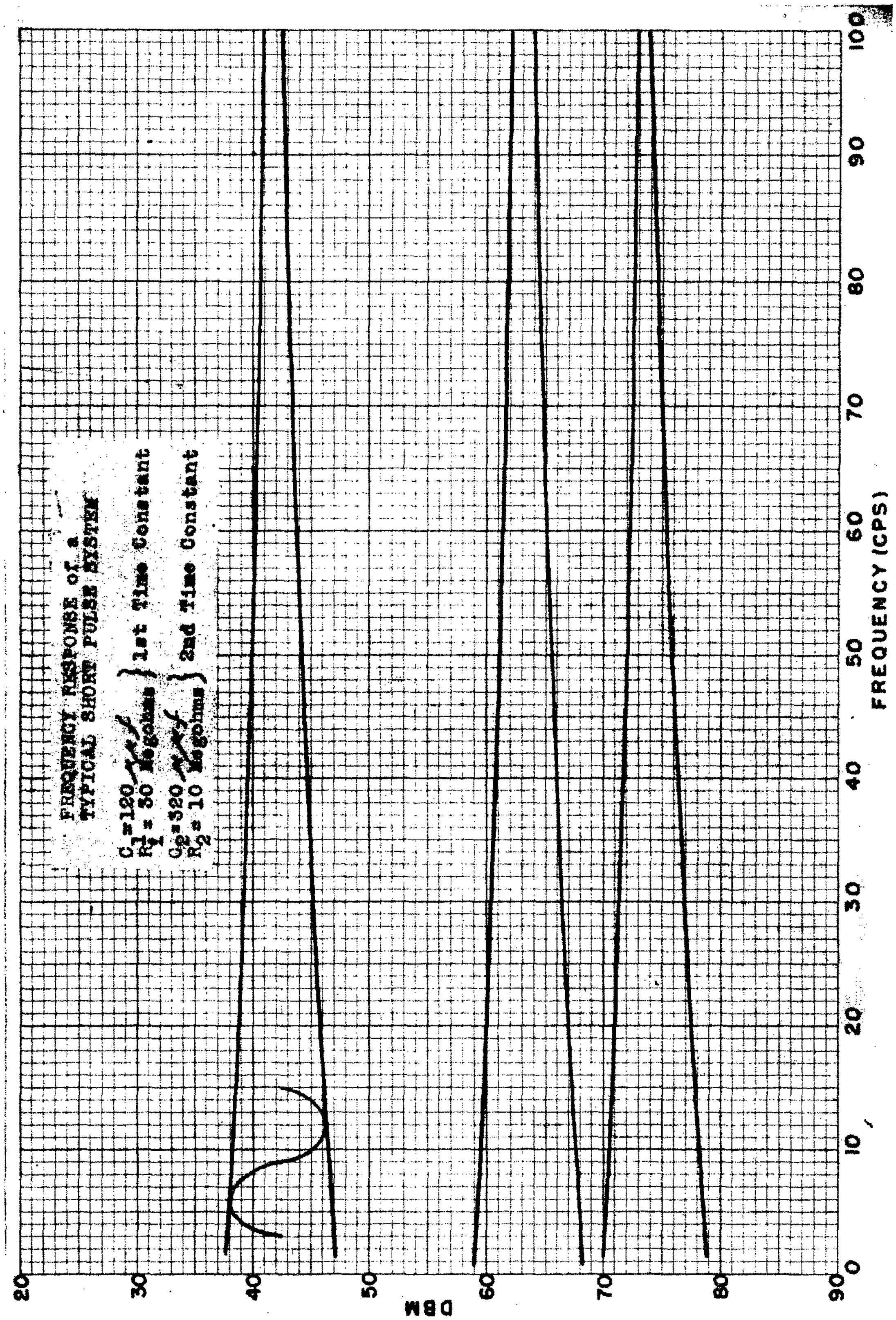


Fig. 11. Frequency Response of a Typical Short Pulse System

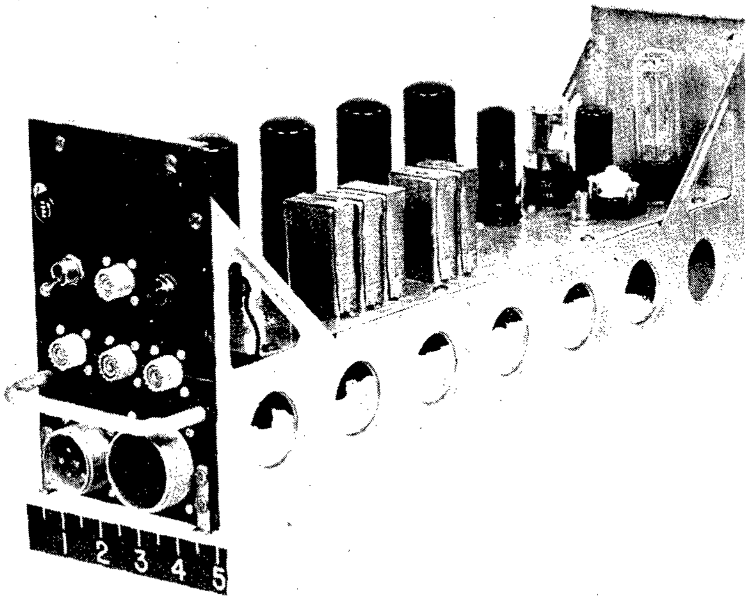


Fig. 12. Square-Wave Generator

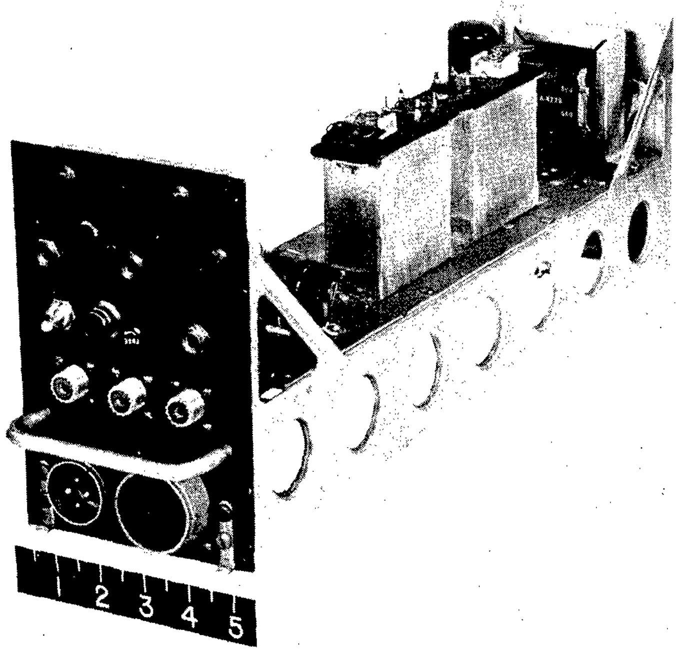


Fig. 13. Filter-Amplifier

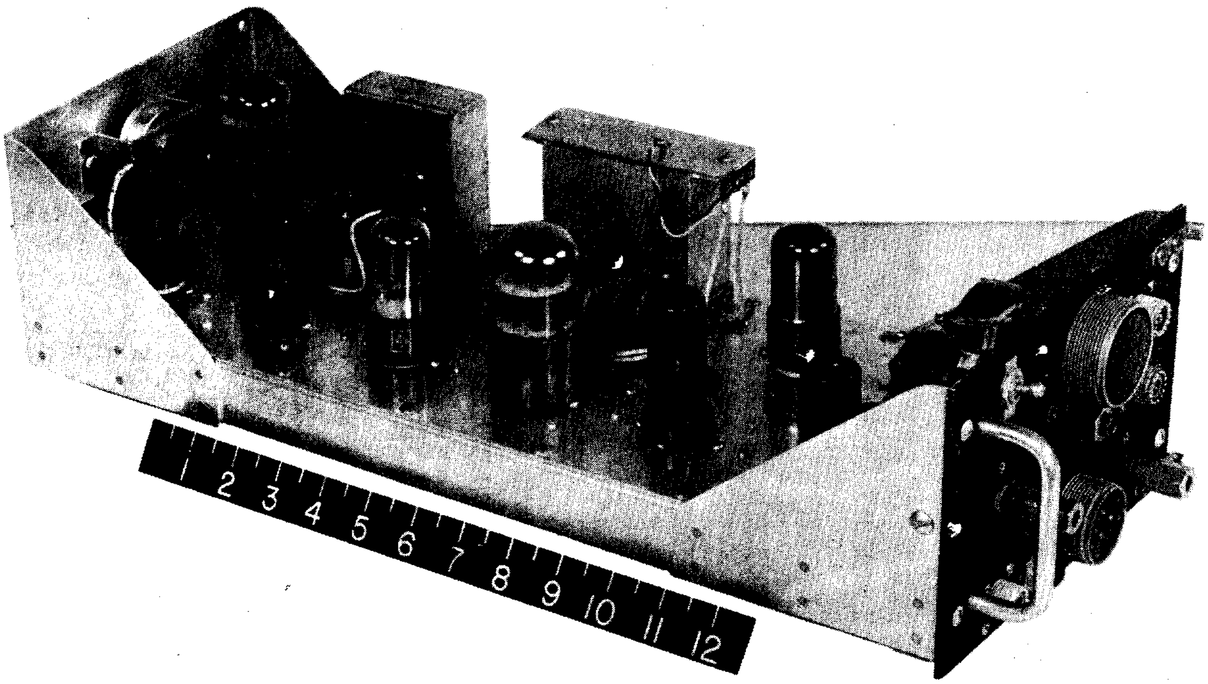


Fig. 14. Pulse Peak Reader

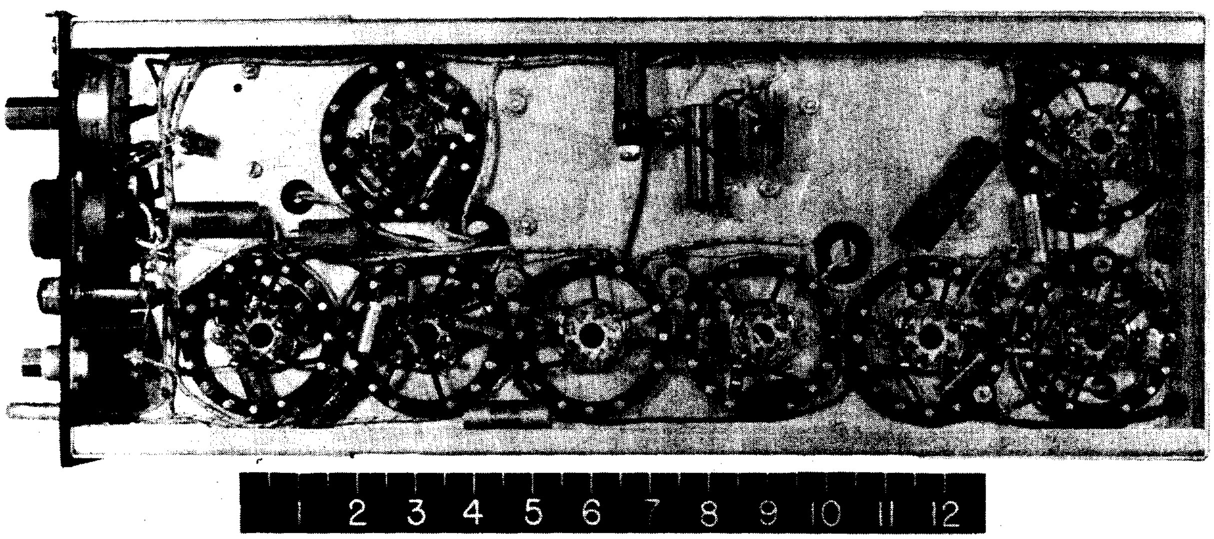


Fig. 15. Pulse Peak Reader (Interior, Bottom View)

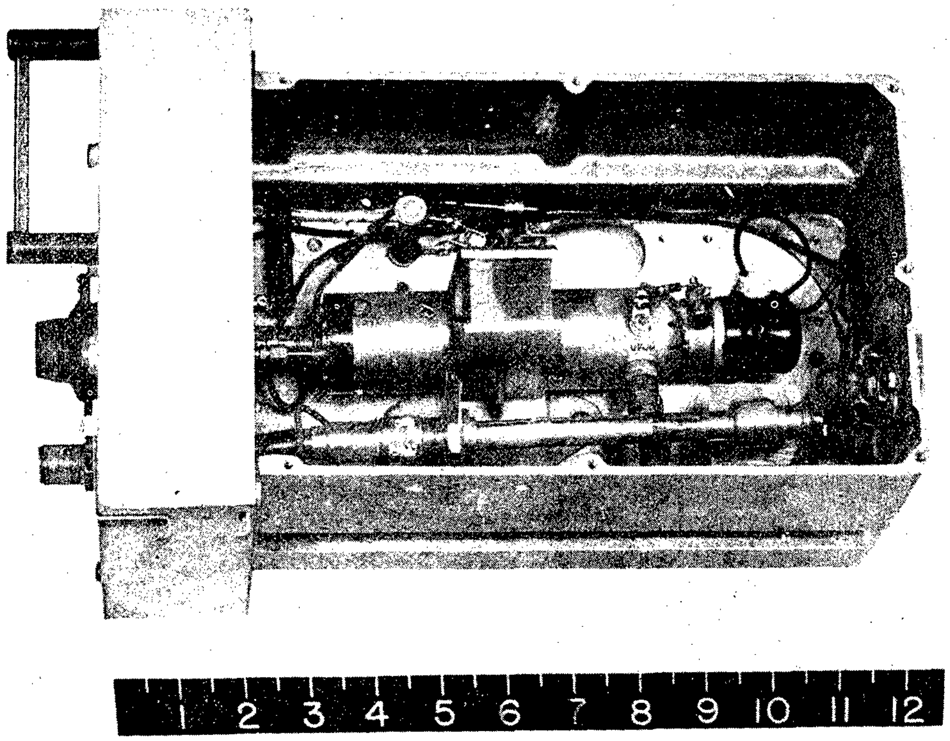


Fig. 16. Electronic Frequency Converter

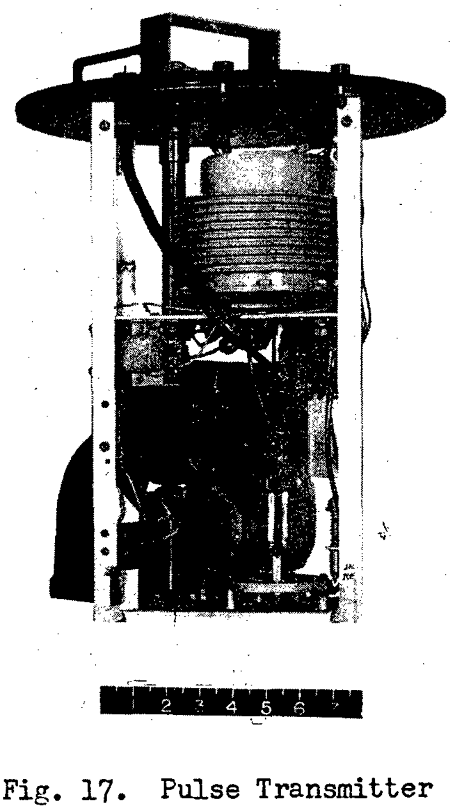


Fig. 17. Pulse Transmitter

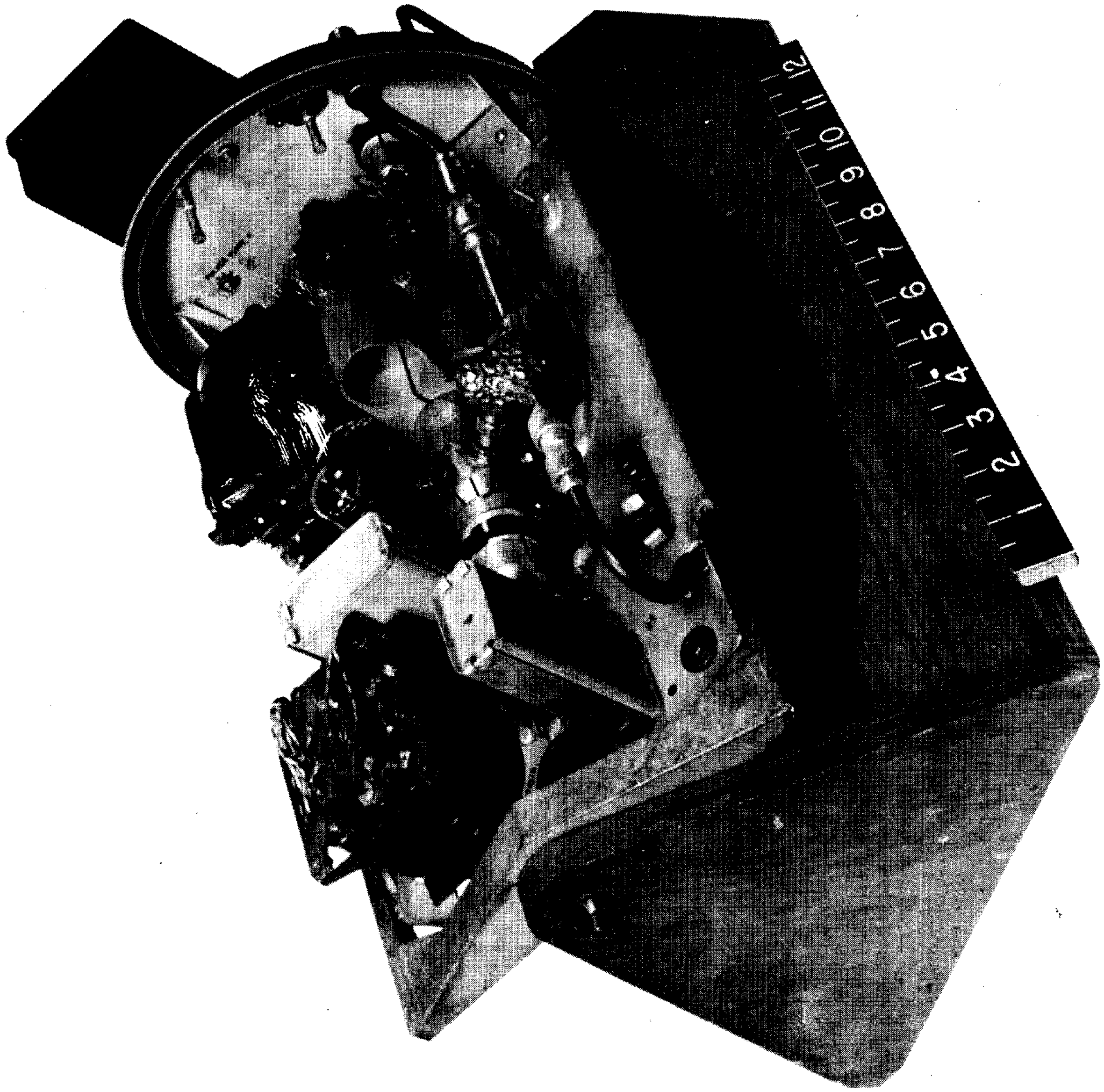


Fig. 18. Pulse Receiver

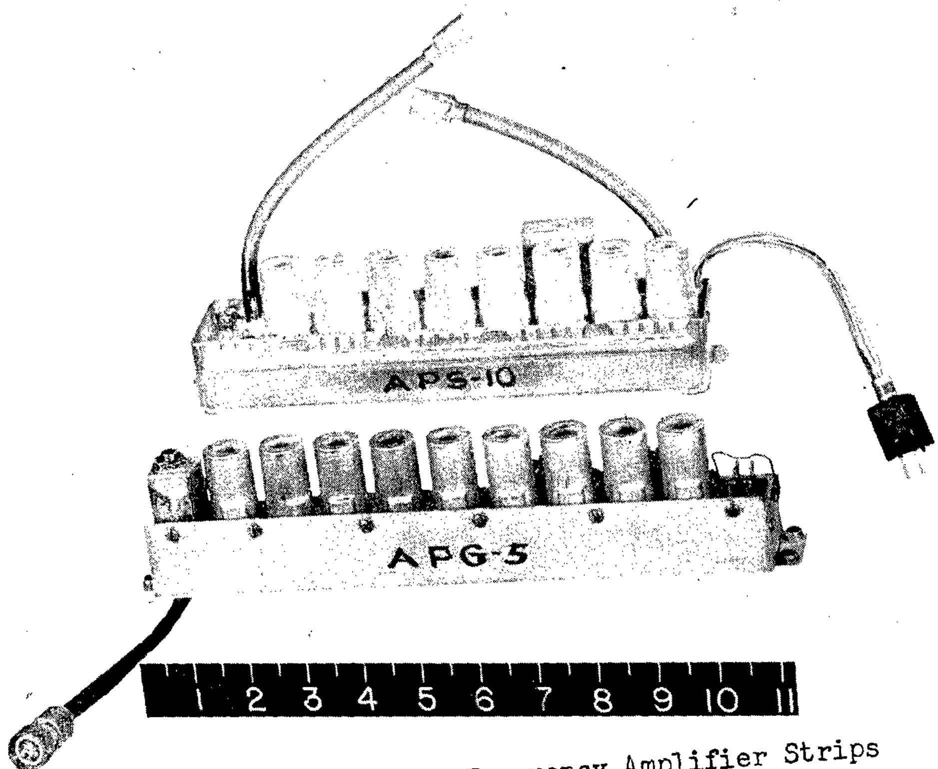


Fig. 19. Intermediate Frequency Amplifier Strips

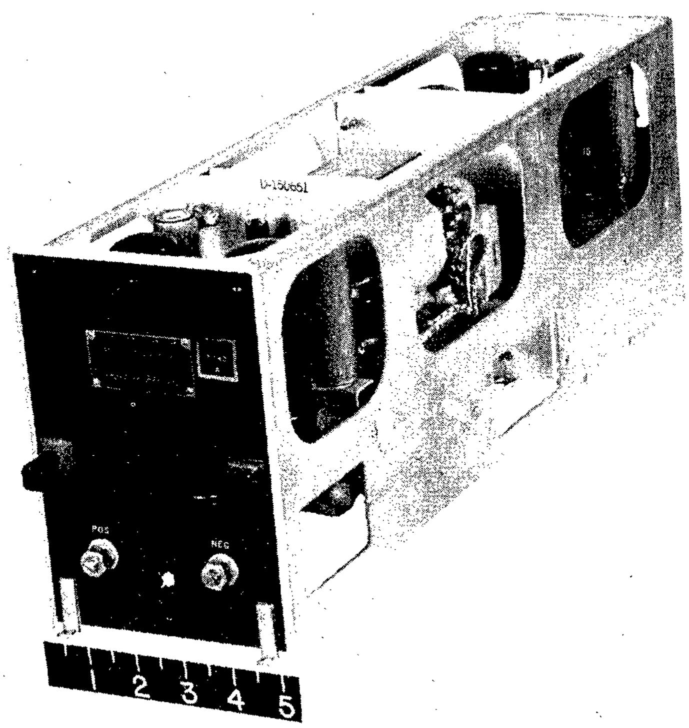


Fig. 20. Rectifier RA-88-A

LIST OF REFERENCES

1. Miller, F. P. and Akerland, G. J. Air-to-Air Electromagnetic Pulse Propagation. Air Force Technical Report No. 6208, United States Air Force, Air Materiel Command, April 1950. (Restricted).

2. Miller, F. P. and Akerland, G. J. Air-to-Air Electromagnetic Wave Propagation. Air Force Technical Report No. 6254, United States Air Force, Air Materiel Command, October 1950. (Restricted).

3. Overcash, F. J. Index of Refraction Measurements With an Airplane Psychrograph. Air Force Technical Report No. 6621, United States Air Force, Wright Air Development Center, August 1951. (Unclassified).

4. Handbook of Maintenance Instructions for Receiving Equipment AN/APR-4. United States Air Force, Technical Order No. AN 08-30APR4-3. 5 December 1944, Revised 12 April 1946. (Unclassified).

5. Handbook - Maintenance Instructions: Radar Set AN/APT-4. United States Air Force Technical Order No. CO AN 16-30APT4-3. 5 June 1945, Revised 26 November 1951. (Restricted).

6. Handbook of Maintenance Instructions for Radio Sets AN/APG-5 and AN/APG-5A. United States Air Force Technical Order No. AN 16-30APG5-3. 21 January 1946. (Restricted).

7. Handbook - Maintenance Instructions: Radio Sets SCR-720-C and SCR-720-D. United States Air Force Technical Order No. AN 16-40SCR720-7. 27 February 1946, Revised 9 August 1950. (Unclassified).

8. Handbook of Maintenance Instructions for Radar Indicator Assembly AN/APA-11. United States Air Force Technical Order No. AN 16-30APA11-3. 1 June 1945. (Unclassified).

9. Handbook - Maintenance Instructions: Radar Sets AN/APT-5 and AN/APT-5A. United States Air Force Technical Order No. AN 16-30APT5-3. 25 May 1945, Revised 20 January 1949. (Unclassified).

10. Handbook - Maintenance Instructions: Radio Sets AN/APQ-13, AN/APQ-13A, AN/APQ-13B, AN/APQ-13C, AN/APQ-13D. United States Air Force Technical Order No. AN 16-30APQ-13-4. 5 June 1945, Revised 25 March 1952. (Unclassified).

11. Handbook - Maintenance Instructions: Radio Set AN/APS-10. United States Air Force Technical Order No. AN 16-30APS10-3. 25 September 1945, Revised 8 February 1950. (Unclassified).

12. Handbook - Maintenance Instructions: Radio Set AN/APN-3. United States Air Force Technical Order No. CO-AN 16-30APN3-2. 7 December 1944, Revised 28 July 1950. (Unclassified).

13. Airborne Components of Airborne Early Warning System, Model APS-20. Publication No. CO-NAVAER 16-5QS-501. Department of the Navy, Bureau of Aeronautics.

14. Handbook of Maintenance Instructions for Radar Set AN/APS-34. United States Air Force Technical Order No. AN 16-30APS34-3. 15 April 1946.

APPENDIX - MODIFICATIONS OF AIR FORCE EQUIPMENTS

The modifications which were made to adapt existing equipments to propagation measurements are described here. Complete information on these equipments may be found in the Handbooks of Maintenance Instructions listed in the List of References (References 4 - 14).

Radar Transmitter T-75/APT-4

The RF unit of the transmitter was modified for square-wave modulation by shorting coils L-104 and L-105 to prevent ringing, as shown in Fig. 21. After modification the transmitter has a peak power of 400 watts, and is modulated by a square wave having a crystal-controlled frequency of 1.818 kc.

Modulator MD-30/APT-4

The modulator was modified as follows (See Fig. 21):

(1) Noise amplifier tubes V201, V211, V221, and V251 were removed.

(2) A 12,500-ohm 25-watt wire-wound resistor was installed between terminals 1 and 7 on terminal board TB-201 for bleeder current.

(3) A UHF receptacle (S0239) was installed on the front panel for connecting the square-wave generator.

(4) A 30-henry choke was installed between chokes L261 and L262.

(5) L261 was shunted.

(6) A wire was connected between the grid end of the 30-henry choke and the receptacle (S0239) which was installed on the front panel.

Signal Generator LAF-3

The LAF-3 Signal Generator was modified for square wave by the following changes (See Fig. 22):

(1) The wires attached to terminal 4 on the socket of tube V105 were removed and taped.

(2) Two 220,000-ohm resistors were wired in series.

(3) The two 220,000-ohm resistors in series were connected between terminal 4 on the V105 tube socket and the juncture of resistors R 130 and R 131.

(4) The wire on the external modulation receptacle was removed and taped.

(5) A wire was connected between the junction of the two 220,000-ohm resistors and the external modulation receptacle.

(6) Tube V104 was removed from its socket.

After the above modifications, the signal generator was checked on a bolometer bridge, and the RF output meter was marked for the proper setting of the plate voltage control.

Radio Receiver AN/APR-4

The AVC circuit of the receiver was modified as follows (See Fig. 23):

(1) Resistor R-117-2 was removed.

(2) Resistor R-117-1 was shorted.

(3) The wire from the S0239 receptacle, at the front panel of the receiver, was connected to resistor R-117-1 for applying the AGC voltage to the IF amplifier of the receiver, the AGC voltage being supplied by either the filter-amplifier or the peak reader.

These changes removed the low-frequency filtering in the AVC circuit of the receiver.

All the 6AC7 tubes in the IF amplifier were replaced by 6AB7 (remote cut-off) tubes. The heterodyne-oscillator tube was removed.

The AN/APR-4 power supply (and related components) was replaced by a RA-88 regulated power supply. This was done by installing a bracket on the AN/APR-4 front panel to hold the necessary AN connector receptacle to connect the RA-88. This power supply was wired into the AN/APR-4 so that the power switch on the receiver would operate in the same manner as before. In addition, the 5Y3 tubes in the AN/APR-4 were removed, and a VR150 was inserted in one of the 5Y3 sockets. The RA-88 was adjusted for 300 volts. This voltage was applied to the high voltage line going to the tuner, while the voltage for the IF amplifier was held to 150 volts by means of a series resistor and the VR tube. The series resistor had a 25-watt capacity and a value of 1200 ohms.

After modification, the receiver can be used with either the filter-amplifier or peak reader.

Tuning Unit TN-17/APR-4

The tuning unit was modified by changing the position of the antenna connection on the butterfly tuner to reduce the VSWR at 245 and 256 mc.

Recorders

One-ma Esterline-Angus Recorders were used with two event markers at the top and bottom margins of the recording tapes. All the top event markers and all the bottom event markers on the different recorders for the propagation links were ganged mechanically. A BC-608-A contactor unit was used for energizing the top marker to indicate time once every minute. A manual push button was used for operating the bottom marker to indicate the horizontal scale. Each recorder was fitted with a junction box to hold a 27,000-ohm damping and calibrating resistor, terminal strip, and receptacles.

Power Supply RA-88

Resistors R802, R803, and R804 were disconnected from the circuit of the power supply for operation of the voltage regulator on less than 175 ma. For operation on a larger current, one or more of the disconnected resistors have to be reconnected.

Radar Transmitter T-85/APT-5A

The following changes were made in the transmitter (See Fig. 24):

(1) Tubes V401, V402, and V103-1 were removed.

(2) The wire in the connecting cable joining point B in the power-supply receptacle to point B in the RF unit receptacle was removed.

(3) The wire from the juncture of R-412-1, R-412-2, R-412-3, and R-412-4 to the juncture of C-204 and C-205 was removed.

(4) The juncture of L-201 and L-202 was opened and L-201 then connected to the positive side of the high-voltage power supply.

(5) The negative side of the high-voltage supply was ungrounded and connected to the positive side of the low-voltage supply.

(6) The lead to the 115-volt tap of the high-voltage supply was switched to the 80-volt tap.

(7) R-205 was shorted.

(8) The cathode end of R-206 was connected to the juncture of R-412-1, 2, 3, 4.

(9) The common series resistance in the screen circuit of tubes V403-2, 3, 4, 5 was increased so that the maximum screen dissipation would not be exceeded.

(10) The meter switch was turned to the cathode-current position and locked.

(11) L-401-2 was disconnected and a 30-henry choke inserted between ground and the juncture of R-411-5, 6, 7, 8. A wire was then run from the juncture of R-411-5, 6, 7, 8 to a UHF receptacle specially installed on the front panel.

(12) An inductive loop was inserted in the cavity inspection hole and a crystal used in series with the loop. Output of the loop is taken through a VHF receptacle for monitoring purposes.

(13) The circuitry of the neon-lamp modulation indicator was removed.

(14) C-404-3B was increased to 4 microfarads to reduce differentiation of the square wave.

The above changes adapted the transmitter for square-wave modulation and increased its power by a factor of 4.

Signal Generator TS-601(XA)/U

The following changes were made for square-wave modulation of the signal generator (See Fig. 25):

(1) Condenser C-19 was disconnected.

(2) The elements of the dual tube V15 were connected in parallel.

(3) The wire from one of the video-pulse receptacles on the front panel was removed. A wire was then run from this receptacle to terminal 5 on the socket of tube V15 for introducing the square wave.

(4) R-36 was replaced by a 10-watt resistor of the same resistance.

After these changes, the signal-generator output was checked on a bolometer bridge. A mark corresponding to 0.1 volt into a 50-ohm line was then indicated on the output meter dial face.

The attenuator of the TS-601(XA)/U was not satisfactory between 80 and 110 db. A length of RG-21 cable was used for additional attenuation in calibrating receivers.

Transmitter T-11/APN-3

The RF unit was modified as follows:

(1) The magnetically operated frequency-changing switch in the RF oscillator circuit was removed.

(2) The power leads to the motor of the contactor switch assembly were disconnected. The motor-driven switch was originally used to apply power intermittently at a constant low repetition rate to the magnetically operated frequency-changing switch.

(3) The synchronous pulse for the RF unit was supplied by the Indicator ID-17/APN-3 at a pulse repetition frequency of 931.09 per second.

Radar Transmitter AN/APS-20

The only alterations to Radar Transmitter AN/APS-20 were removal of the antenna reflector in the airplane installation, and lowering of the original horn feed by means of a length of flexible waveguide to eliminate possible reflections from the airplane surface.

Special Tuning Unit for AN/APR-4 at 2880 Mc

A special tuning unit (Figs. 16 and 26) was designed, as Tuning Unit TN-54/APR-4 was not satisfactory for reasons of drift and loss.

Short-Pulse Transmitter for 3295 Mc

The RF assembly of the transmitter (Fig. 27) is the same as that in the Radio Set SCR-720-D except that:

(1) A 2J22 magnetron is used.

(2) A special magnetron coupling is used.

(3) A Transtat, or variable autotransformer, was inserted in the line to the primary of the high-voltage transformer in Modulator BC-1142-A for adjusting the peak power of the transmitter.

Radar Receiver RT-39A/APG-5

The following changes were made:

(1) The TR Box and transmitter lighthouse tube cavity were removed.

(2) The two rectifier tubes 2X2 were removed.

(3) The rectifier tube 5Y3 was removed.

(4) The 3E29 and its Amperite type regulator were removed.

(5) The RA-88 power supply furnishes 300 volts to pin No. 8 on the 5Y3 socket.

(6) The R-F cavity in the plate circuit of the receiver lighthouse tube was adjusted for higher-frequency operation.

(7) The resistance in the plate supply lead was adjusted so that the lighthouse tube would oscillate at the higher frequency.

(8) A special mixer assembly (Figs. 16 and 26) was used.

(9) The 6AK5 tube in the third IF stage was removed and a remote cut-off tube 6BA6 substituted to improve the dynamic range and semilog characteristics.

(10) The 10-megohm resistor R-180 between the last two tubes in the IF amplifier was removed.

(11) The 6800-ohm resistor in the cathode circuit of the last tube in the IF amplifier was removed. The video gain control potentiometer in the peak reader then became the cathode resistor.

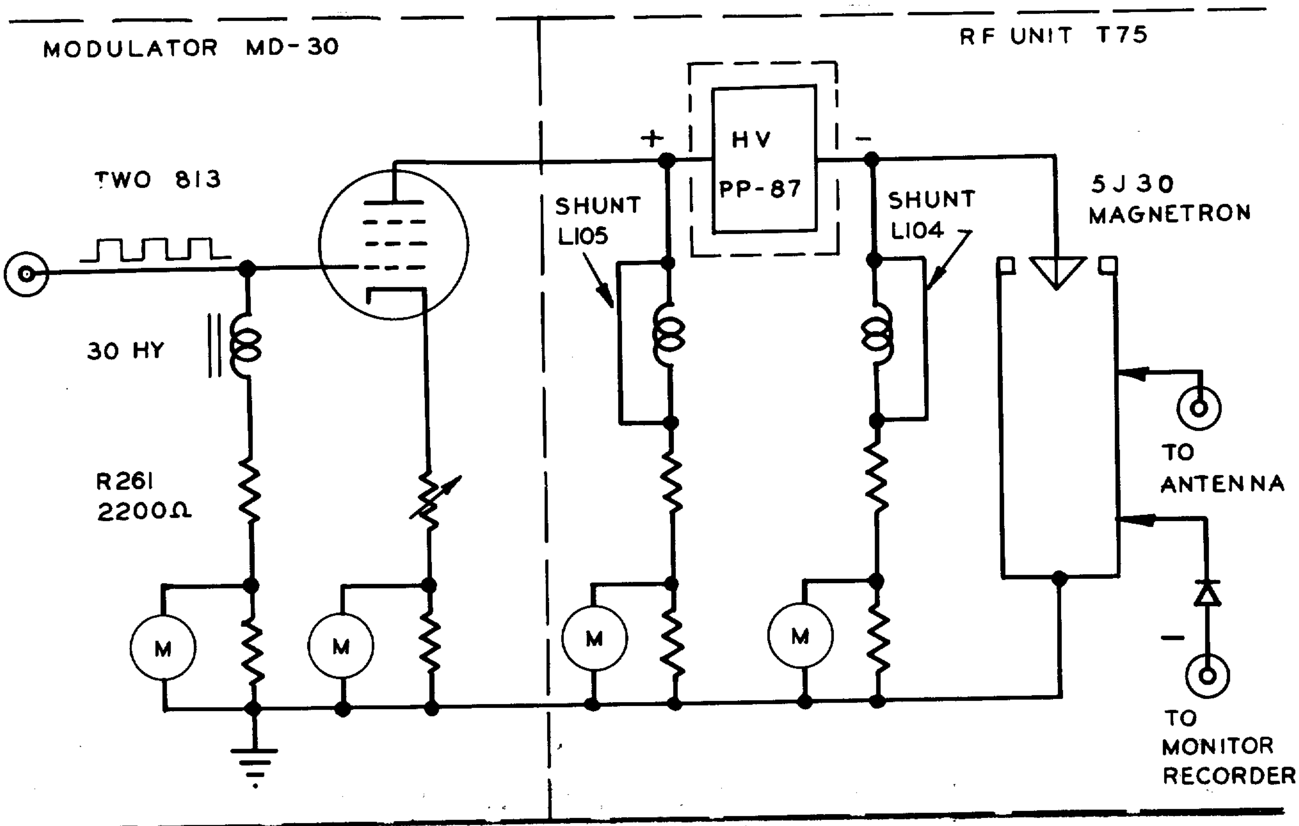


Fig. 21. Simplified Schematic - AN/APT-4 Transmitter Modifications (245 MC)

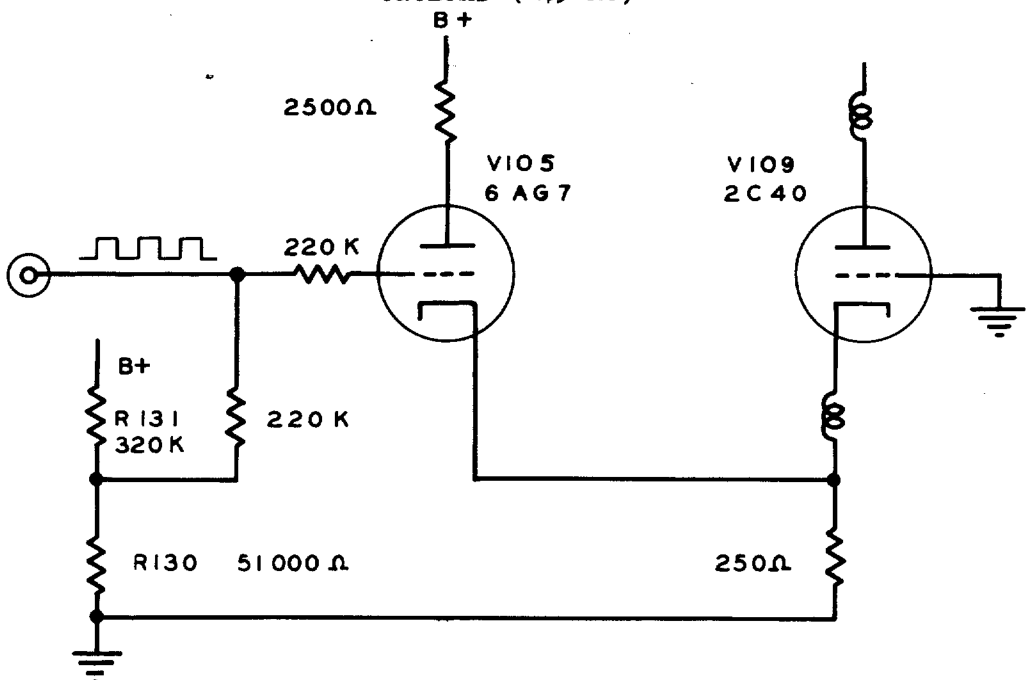


Fig. 22. Simplified Schematic - LAF-3 Signal Generator (245 MC) Modifications

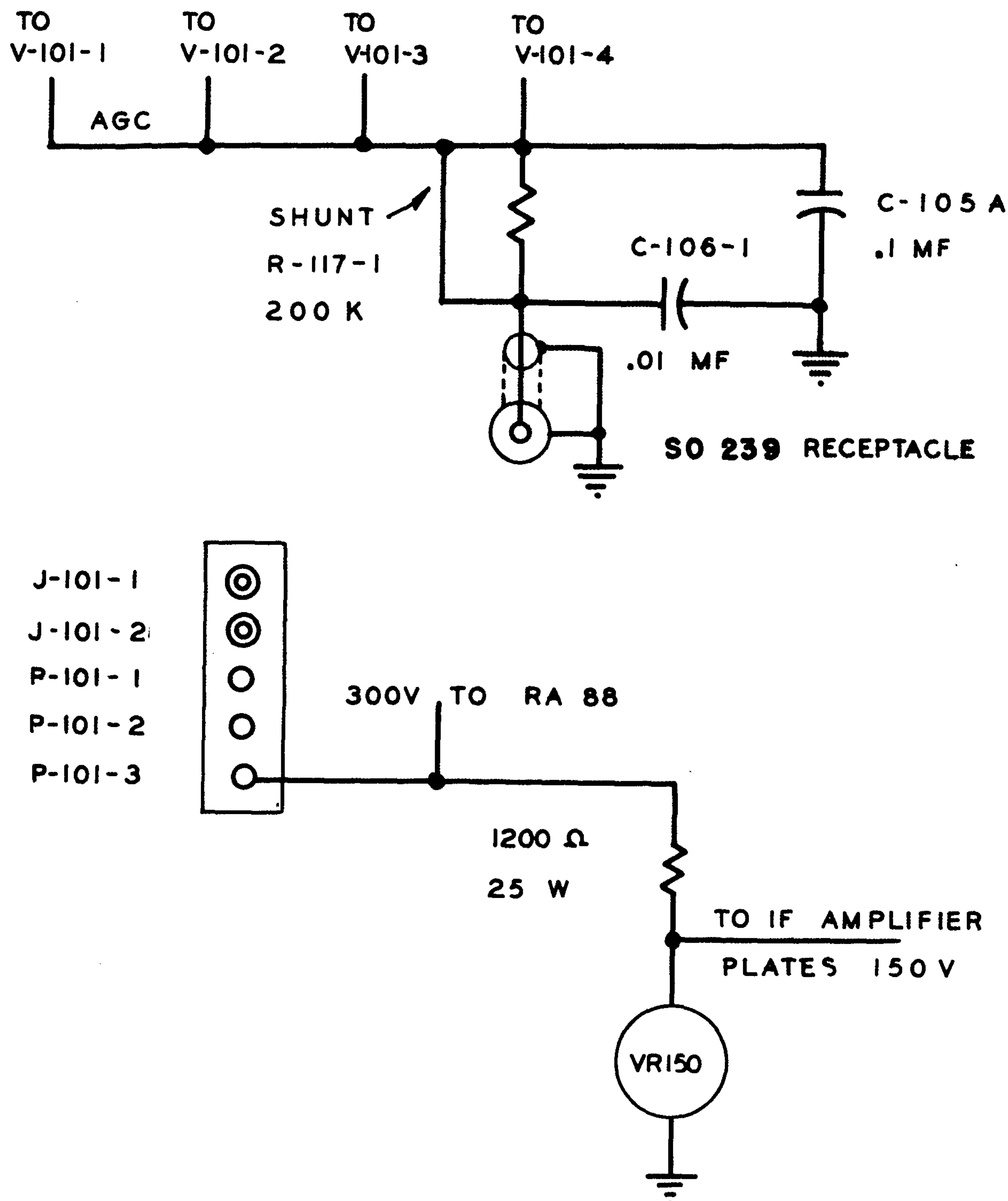


Fig. 23. Simplified Schematic of AN/APR-4 Changes

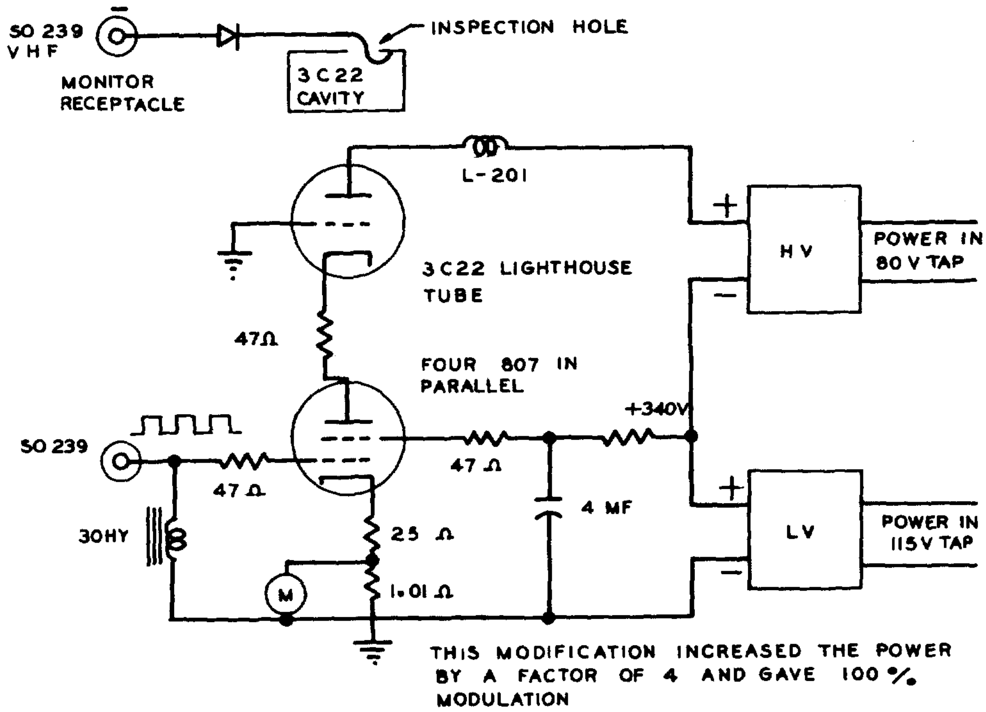


Fig. 24. Simplified Schematic: 1000-MC Transmitter Modifications

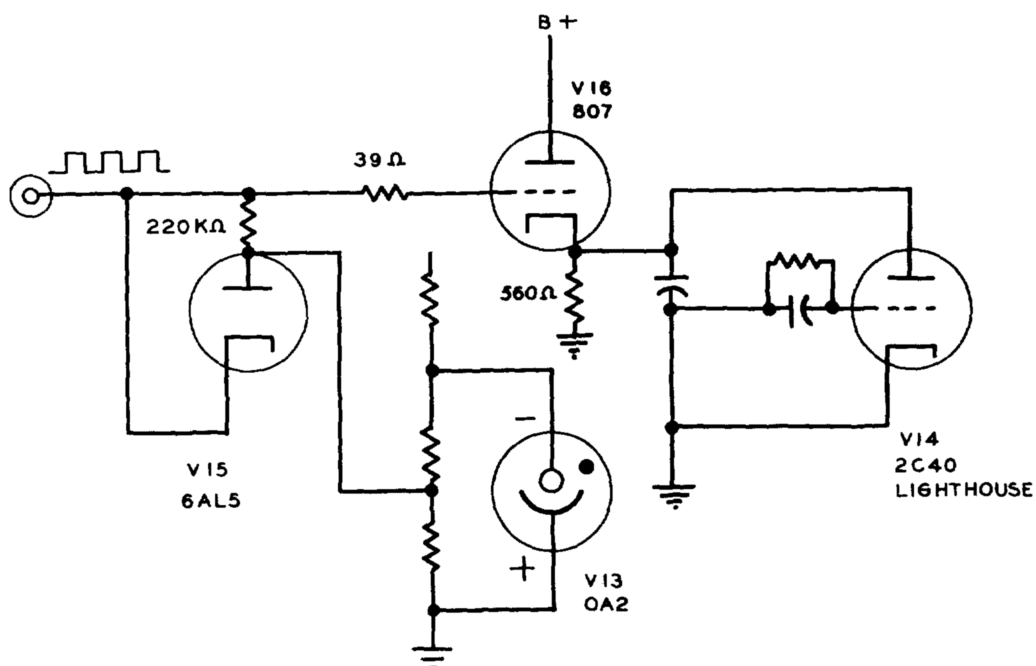


Fig. 25. Simplified Schematic: TS-601 Signal Generator (1000 MC) Modified for Square Wave Modulation

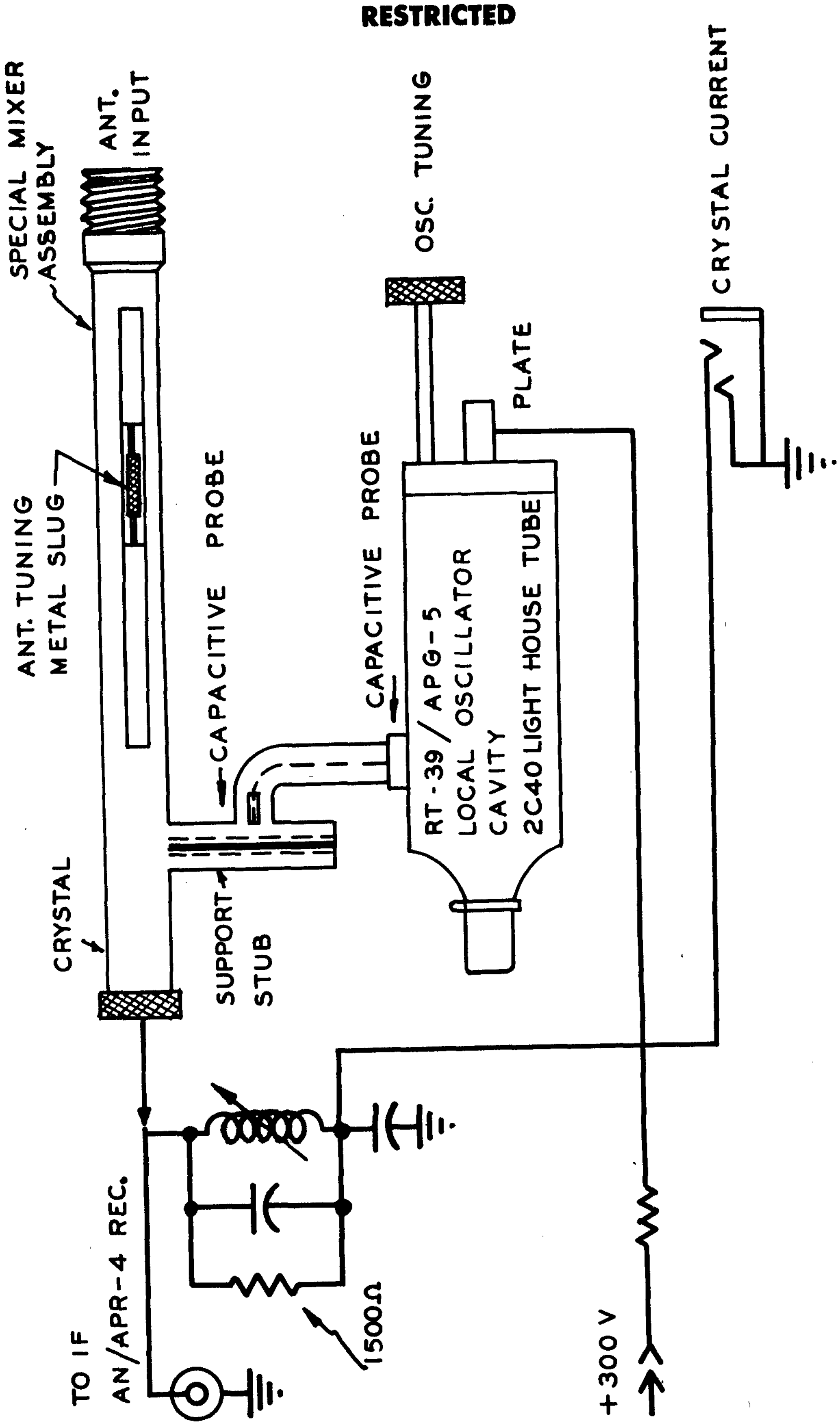


Fig. 26. Local Oscillator and Special Mixer Assembly

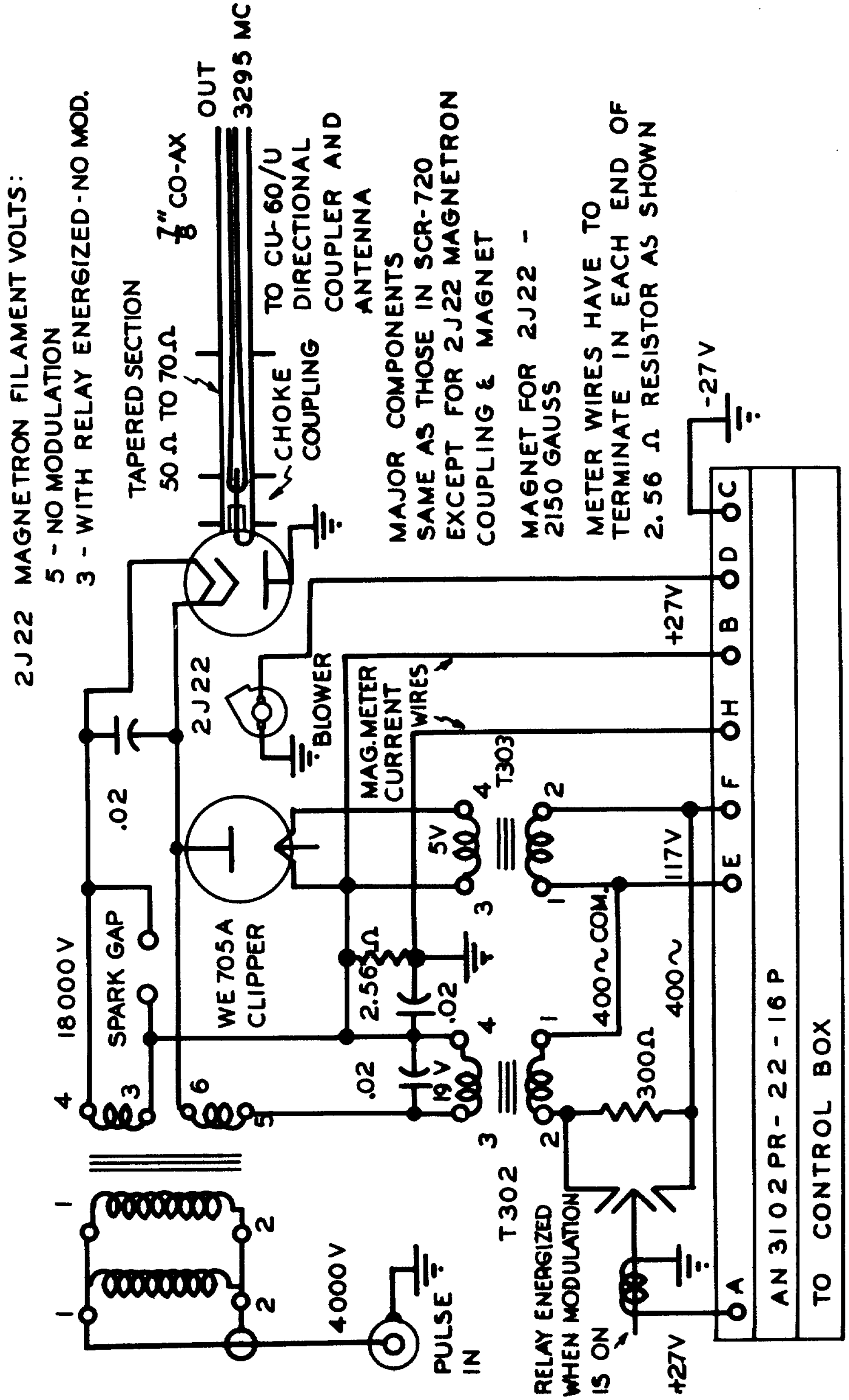


Fig. 27. Schematic Diagram: 3295-MC Transmitter

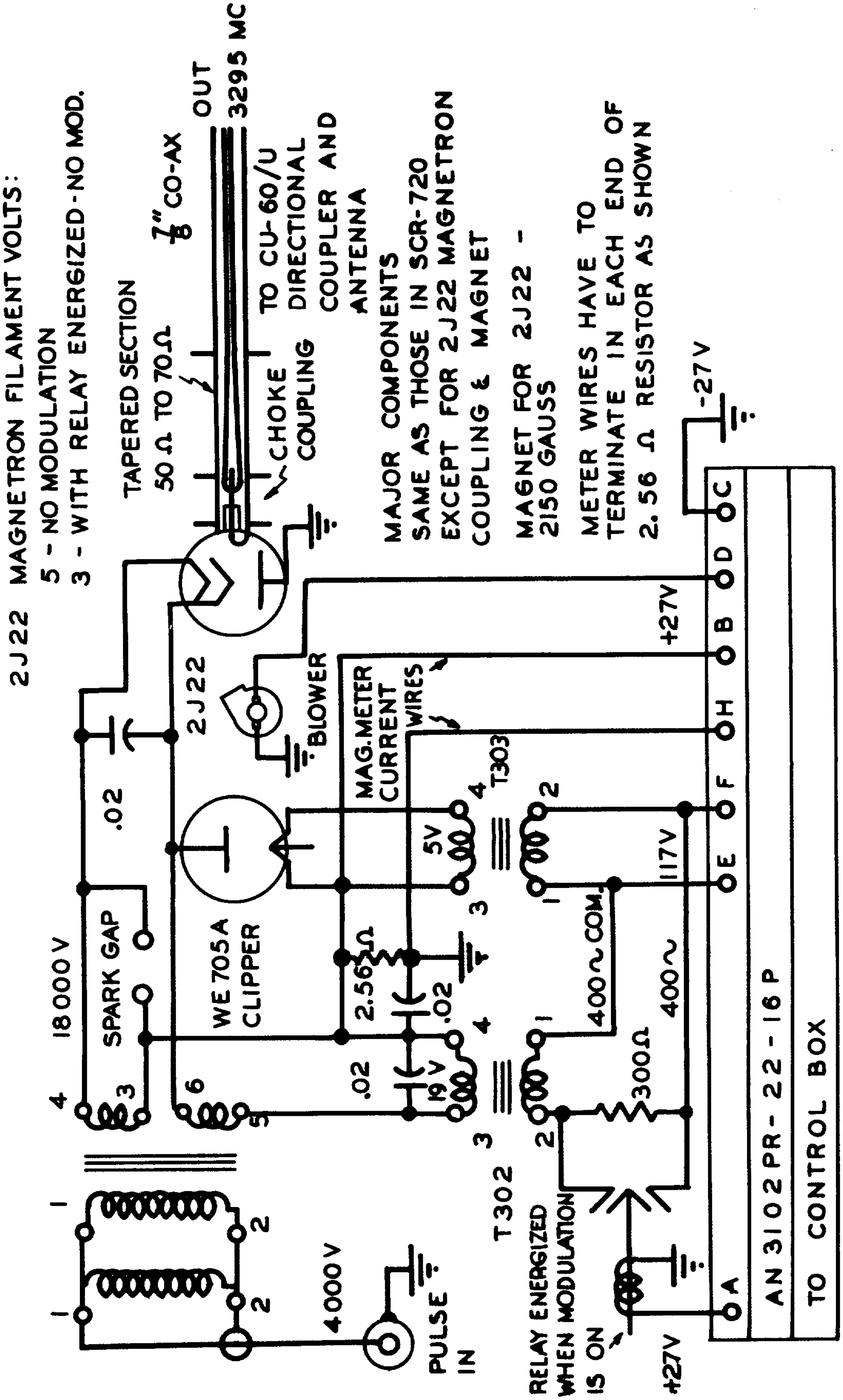


Fig. 27. Schematic Diagram: 3295-MC Transmitter

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